NOV 9 1931

THE GEOGRAPHICAL JOURNAL

Vol LXXVIII No 5 November 1931

ANTARCTIC RESEARCH BY THE *NORVEGIA* EXPEDITIONS AND Others . . . . . Professor Olaf Holtedahl 401

THE PHYSIOGRAPHY OF THE WESTERN MACDONNELL Ranges, Central Australia . . . . . C. D. Madigan 417

PROBLEMS OF THE EARTH'S CRUST 433

THE BRITISH ARCTIC AIR ROUTE EXPEDITION 456

THE STUDY OF NATURAL CATASTROPHES: Review Lord Howard of Penrith 457

CORAL REEFS AND ATOLLS: Review . . Dr. Cyril Crossland 460

REVIEWS MONTHLY RECORD CORRESPONDENCE

SOCIETY'S NOTICES . . iii CONTENTS . . v

THE ROYAL GEOGRAPHICAL SOCIETY, LONDON S.W.7
EDWARD STANFORD LTD. 12 LONG ACRE W.C.2
PRICE TWO SHILLINGS

THE GEOGRAPHICAL JOURNAL is published monthly by the Royal Geographical Society. It contains the papers read at the Meetings of the Society, with the discussions: illustrated with original photographs, and with maps drawn from the authors' surveys by the draughtsmen of the Society. It contains also Articles on geographical topics; Reviews of important books and maps; a Monthly Record of Geographical work; and occasional Letters from Correspondents.

The *Journal* is sent free each month to all Fellows of the Society, and is sold to the public at Two Shillings per number through Messrs. Edward Stanford Ltd. of 12 Long Acre W.C.2 and 29 Charing Cross S.W.1; Messrs. George Philip and Son Ltd. of 32 Fleet St. E.C.4; Messrs. Sifton, Praed and Co. Ltd. of 67 Saint James St. S.W.1; and the International News Company, New York City, U.S.A. It may also be ordered direct from the Office of the Society at Twenty-seven Shillings per year, post free. It is registered for transmission to Canada by Canadian Magazine Post.

The Postal Address of the Society is
KENSINGTON GORE, LONDON, S.W.7
The address for Inland Telegrams is
OBTERRAS SOUTHKENS LONDON
and for Cablegrams
OBTERRAS LONDON
The Telephone Number is KENSINGTON 2648

The
GEOGRAPHICAL JOURNAL

Vol LXXVIII No 5 R.G.S. *November 1931*

ANTARCTIC RESEARCH BY THE *NORVEGIA* EXPEDITIONS AND OTHERS: *A paper read at the Evening Meeting of the Society on 15 June 1931, by*

PROFESSOR OLAF HOLTEDAHL

I HAVE come to this meeting in order to give a survey of recent Norwegian research in the Antarctic, the research work which has been carried on during the last five seasons on the initiative and at the expense of Consul Lars Christensen, one of the leading men in modern Norwegian whaling.

Consul Christensen has here followed in his father's footsteps, it being his father, C. Christensen, who first and foremost has the honour of sending out in 1892 and 1893 the *Jason* expeditions to the West Antarctic, expeditions which had the object of investigating the possibility of lucrative whaling and sealing, but which also, under the eminent leadership of Captain C. A. Larsen, made extremely important discoveries in geography and natural history on the west side of Weddell Sea, where he penetrated much farther south than any previous explorer had succeeded in doing.

Consul Lars Christensen started the first work of exploration and research in the season of 1926–1927, when the whaler *Odd I* was sent, in January 1927, from South Georgia *via* the South Shetlands and westward towards Peter I Island. This island was discovered by the Russian Admiral v. Bellingshausen in 1821, and again seen on the second Charcot Expedition in 1910, although neither of these expeditions actually reached the island. The main task of the *Odd I* expedition was to seek new fields of operation, since whaling at South Shetlands, where at that time the main part of the whaling fleet was engaged, had deteriorated, but the programme also comprised a somewhat close investigation of the said island which hitherto had only been seen from a distance. The vessel had on board sounding apparatus, and a trawl for the investigation of the bottom of the sea near the island, and means of preserving the material collected. The leader of the expedition was Mr. Eyvind Tofte,* and the master of the vessel Captain Ant. S. Anderssen. The great difficulty was the coaling

*In *Norsk Geografisk Tidsskrift*, vol. i, 1927, p. 462, Mr. Tofte has given an account of the *Odd I* Expedition. See also for this (and the first *Norvegia* expedition) an article by Mr. Bjarne Aagaard: "Antarctic Whaling and Exploration," *The Scottish Geographical Magazine*, vol. xlv, 1929, p. 23.

question, since *Odd I*, with full bunkers, had sufficient only for thirteen to fourteen days, although it is true with a speed of no less than 10 knots. It was therefore necessary, when the boat left Deception Island in the South Shetlands on January 12, where it had received coal from the floating factory *Pythia*, to carry a quantity of coal on deck, a procedure which of course is somewhat risky for such a low and small vessel as a whaler of about 100 feet in length.

After sailing some distance to the south-west in the lea of the large islands of the Palmer Archipelago, the course was set, on the 13th, direct towards Peter I Island. The waters there were free from ice. On the morning of the 17th the island appeared in sight straight ahead. After cruising about for a time a landing was attempted at the projecting cape on the west side, which was called Cape Ingrid Christensen, but on account of the heavy swell the attempt had to be abandoned. Dredging was made however close to the shore, and in that way there was secured besides biological also geological material telling about the character of the rocks, which were of volcanic origin.* Soundings were also made near the shore. However, hope had not been abandoned of a landing, but now a wind arose and, after cruising round for a while, it was decided to leave the island, particularly on account of the small stock of coal: there were only 50 tons left. The vessel was then steered southwards towards the edge of the pack-ice, which was reached after only one hour's sailing. They then proceeded along the edge of the ice to the east, mostly in thick weather, with fog and at times snowstorms. As they proceeded eastwards the edge of the ice became very irregular, with long projecting capes. For several days the voyage was continued in fog without observation being possible, and when the weather cleared up in the afternoon of the 21st they were near the Palmer Archipelago. They then proceeded on the outside of the islands, and on the 22nd were again in port at Deception Island.

The chief aim of the voyage was, as mentioned before, to investigate whether there was a good stock of whales in those waters. In reality, during the ten days of the expedition practically no whales at all were observed, so that there was no encouragement to attempt capture.

The first *Norvegia* expedition then took place in the season 1927–1928, a season when research of many kinds was carried on, research in which I myself took part. As the secretary of the Norwegian Geographical Society I received at an early stage from Consul Christensen notice of the *Odd* expedition, of which I gave a short account in a newspaper article and, furthermore, in the Journal of the said Society I gave a preliminary report of the scientific results.† This work crystallized an idea which I had had for several years but which occupations of another kind had kept in the background, namely, to make use of the opportunity afforded to Norwegian science by our large whaling fleet in the Antarctic for research in the south. I submitted to Consul Christensen a plan of such work, especially in the South Shetland region, and he was at once interested in the matter. He was however able to inform me that he had a plan

*The material has been studied by Mr. O. A. Broch, who has published a report on his results in a paper, "Gesteine von der Peter I–Insel, West-Antarktis," published in *Avhandlinger utgitt av Det Norske Videnskaps-Akademi*, Oslo 1927.

†*Norsk Geografisk Tidsskrift*, vol. i, 1927, p. 473.

of his own, viz. to send an expedition vessel to more easterly waters, including Bouvet Island, a district in the closer investigation of which Christensen had already for many years been interested. Soon after, in April 1927, he purchased a vessel, which was named the *Norvegia*, a wooden ship built in 1919 for sealing in the Arctic, 125 feet long, 250 tons d.w., with a complete sailing equipment and a steam-engine of 350 h.p., which in smooth water could give a speed of 7 knots. As master of the *Norvegia* there was appointed Captain H. Horntvedt, and two young scientists were to take part in the expedition, for meteorological and oceanographical (including biological) research. Those appointed were Haakon Mosby, who for a time had been Nansen's assistant, and a young zoologist, Ditlef Rustad.

As a geologist I had no very great interest in an expedition mainly based upon marine investigation, and it was decided that Christensen should defray my expenses and those of a zoologist, Dr. O. Olstad, for a voyage to various western Antarctic lands. Assisted by vessels belonging to Christensen's whaling fleet, and possibly also by other vessels, we were to carry on investigations as best we could. When the *Norvegia* had explored the eastern waters it was to proceed westward to South Shetland, where the vessel would be placed at our disposal for further research work.

The *Norvegia* was well equipped for the projected ocean investigations, and on September 14 left Sandefjord harbour. Two months later the vessel was at Cape Town, where as much coal as they dared was taken on board, including 60 tons in sacks on deck. Her course was then set towards Bouvet Island as preliminary object. I will here say a few words about that little island, based upon an account given by Consul Bjarne Aagaard, who has recently published a large work on Norwegian whaling and exploration in the Antarctic, a work which includes also detailed reports on the *Norvegia* expeditions.*

The island was first seen by a French naval officer, Lozier Bouvet, who for the French India Company in 1738 set out to investigate the southern land, Terra Australis Incognita, which was then rumoured to exist and to contain great wealth. They passed Madeira on July 31, and after calling at the coast of Brazil, they proceeded southward. In December they encountered a great number of icebergs in fog and snowstorm, and they saw a number of penguins and seals. Finally, on January 1, they discovered a lofty coast and snow-covered land. They named it Cap de la Circoncision, and assumed it to be a part of the great southern continent. As a matter of fact what was seen must have been the north-western part of Bouvet Island. The vessels lay in those waters for twelve days, but as the season was far advanced and there was much scurvy on board, orders were given to find less inclement regions, after the vessel had searched in vain for new land to the east. The regions in the south were not found to be especially inviting.

In the following years several explorers searched for Bouvet's Cap de la Circoncision, but the first to see land in those waters was Captain James Lindsay, on the English sealer *Swan*, in 1808. An island was then discovered and was given the name Lindsay Island. This must have been Bouvet Island. The first to go on land on the island was the American sealer B. Morrell in December 1822. In 1825 two of the Enderby Brother's ships, under Captain Norris,

*'Fangst og forskning i Sydishavet,' vols. i–ii. Oslo (Gyldendal Norsk Forlag), 1930.

reached an island, which was most probably the same, but which they named Liverpool Island. Still another island, named Thompson Island, was reported, and on one of the islands landing was effected.

In the latter half of the last century several American sealers passed the island, but we owe a closer knowledge of it to the great German expedition on the *Valdivia* in 1898–1899. A little to the west of the positions given (at about 54° 26′ S. and 3° 24′ E.) there was found an island which was named Bouvet Island and which was then for the first time more closely known and described. However, they did not succeed in going on land. Fruitless attempts were made to find other islands. Bouvet Island has later on been seen at a distance from various research vessels, but it was not found possible to land, and no more islands were discovered.

We will, then, return to the *Norvegia* expedition of 1927–1928.* Even before she reached "The Roaring Forties" the little vessel came into contact with storm and sea. On account of the sacks of coal on deck it was difficult to find an outlet for the water which poured on to the ship, and a great number of sacks had to be thrown overboard. After a time the first iceberg was passed, and the surface temperature of the sea sank quickly. On November 30 they had ahead the first glimpse of Bouvet Island, but on approaching it there was a snowstorm, and it was not possible to row ashore. The next day however, December 1, there was fine weather and, after having looked about for a landing place, the vessel anchored on the west side of the island, and a few hours later a landing was effected. Some stores were set on shore and a flag-pole bearing the Norwegian flag was erected.

Already the next day soundings were taken around the island, in spite of the fact that the sea was rather rough. In the following days the time was spent partly in taking soundings and partly in sealing operations amongst the large numbers of fur seals which were found, especially on a little flat island at the south-west point, an island called Lars Island, a place where it was found possible to go on land.

Whilst seeking shelter against a heavy south-west storm the *Norvegia*, on December 3, struck a submerged rock off the north coast of Bouvet Island and sustained considerable damage. However, sounding and sealing operations were continued for several weeks until January 1. During these weeks the weather was mostly stormy with high seas, and the conditions were often quite dangerous for a ship on that unprotected coast. It also happened after going ashore that the rowing boats which had brought the men in were scarcely able to get back to the *Norvegia* again. In the course of that time the leak sustained by the vessel when she ran aground increased.

The *Norvegia* then set off to the south, where oceanographical work was to be made, and there furthermore was the possibility, if they proceeded far enough, of making interesting geographical observations. Several stations had previously been taken in the neighbourhood of Bouvet Island, and farther on the way south five stations were taken with observations of water and plankton at a series of depths down to 2000 metres, until on January 7 the pack-ice stopped further progress southwards at about 60° S. The leakage had

*A brief account of the research work performed during that season is given by H. Mosby and O. Holtedahl in *Norsk Geografisk Tidsskrift*, vol. ii, 1928, p. 215.

West coast of Peter I Island *Phot. E. R. Hansen*

Looking south from Peter I Island

UNIV OF MICH.

Royal Bay and Ross Glacier, South Georgia

then further increased so that the hand pumps had to be used in addition to the steam pumps, and in such circumstances and in view of the small stock of coal, it was not considered advisable to try to force a way farther south. The course was then taken to the west along the edge of the ice and later on to South Georgia, where repairs to the vessel were to be undertaken. Also in these more western waters a number of oceanographical stations were taken. On January 22 the *Norvegia* entered Grytviken harbour in Cumberland Bay, and was soon after examined by a diver, who found that the damage was very considerable. Amongst other things the keel was broken and extensive repairs were therefore necessary.

Mosby and Rustad however did not abandon scientific research, but by the willing assistance of several whaling companies were afforded an opportunity of carrying on oceanographical and other studies in several of the bays of the island.* Rustad was able, on board the sealing vessel *Diaz*, to visit a number of places on the west coast of South Georgia, and brought back from Annenkov Island fossiliferous rocks of considerable interest.

I will now give a brief description of the work performed by Olstad and myself in the same season. Olstad went south from Oslo in October, but on account of my work I could not leave until November. During the first part of the time Olstad carried on zoological investigations at Deception Island, where I met him in January. My tour southward to South Shetland did not proceed quite according to programme, because the 8000-ton steamer on which I was a passenger, and which was bound for Deception with a cargo of coal, had her rudder damaged in a storm off the Falkland Islands, and after drifting for several days towards the north-east we were taken into Port Stanley by a Norwegian steamer. However I was able to proceed southward on the floating factory *Falk*, which had been obliged to go up to Falkland to get coal from the ship on which I had arrived.

I spent some interesting days in the region of drifting ice north-east of South Orkney, where extensive whaling operations were in progress, and was then offered a passage on a whaler westward to Deception. On that tour I had an opportunity of endeavouring to land on the large Clarence Island, the most eastern of the South Shetlands, and after some difficulty on account of the breakers I succeeded in going on land and in collecting a quantity of geological specimens, the only ones so far obtained from that island.

In the whaler *Tordönn* Dr. Olstad and I went from Deception southward to Port Lockroy, in the Palmer Archipelago, where, with the floating factory *Pythia* as basis, we remained for about one week. Our stay there was from a scientific point of view very interesting to me, for I made the acquaintance of scenery which in detail resembled that which must have existed on the coast of Northern Norway during part of the Ice Age. We have there in the north a physiographical phenomenon which we term the "strandflat," an irregular coastal platform, cut in the rock, a platform concerning the formation of which

*On the biological material of the first *Norvegia* expedition, two reports dealing with the crustacean groups Euphausiacea and Mysidacea have already been published by Mr. Rustad, "Scientific Results of the Norwegian Antarctic Expeditions, 1927–28 and 1928–30, instituted and financed by Consul Lars Christensen." Nos. 5 and 6. Published by *Det Norske Videnskaps-Akademi i Oslo*, 1930.

there has been much discussion. There were now exactly the same landscape features seen in the Palmer Archipelago, only the platform was covered with ice, a special kind of foreland glacier which excavates the sides of the steep mountains inside the glacier and steadily increases the breadth of the platform. There can be no doubt that the platform in Norway to a great extent was formed in a similar manner, and this gives us an opportunity of drawing conclusions as to the geographical and climatic conditions in the north when this "strandflat" was formed.

There are beautiful landscapes at Port Lockroy and much of interest to a geologist. It might be thought that the country is now as greatly glaciated as a country can be, but we see nevertheless glacial polishing and striae where no considerable covering of ice is to be found at the present time. This however may rather be connected with a former higher level of the land-mass than with changed climatic conditions.

From Port Lockroy Olstad and I returned to Deception, where for some days I made excursions in order to study the geological structure of this volcanic island.

As has been already mentioned, the original plan was that the *Norvegia* should have been placed at our disposal during the later part of the season, but instead the vessel, as we have heard, had to be repaired in South Georgia. Dr. Olstad and I therefore had to get on as best we could. On January 31 we left Deception on the transport ship *British Isles*, and five days later were in Prince Olav Harbour in South Georgia. In February we carried on investigations each in his own special branch on the coasts of South Georgia, where I had occasional opportunities of making use of the whaler mentioned in connection with the foregoing season, *Odd I.* My observations of geology and physical geography from this, as from other places mentioned above, were recorded in a paper which appeared in December 1929.* During my stay in the south I came into connection with various interested whalers who procured for me geological material from places which I had personally not visited, for instance from George Island in South Shetland, Signy Island in South Orkney, and from Clerke Rocks, 70 kilometres south-east of South Georgia, barren rocks the geology of which has hitherto been unknown.

During his stay in South Georgia Dr. Olstad was mainly engaged in biological studies of seals and birds, but he also studied two land mammals, both of which had reached the island with human beings, namely the rat and the reindeer.† The occurrence of reindeer in South Georgia is due to Norwegian whalers, who on several occasions took with them tame reindeer, eleven animals in 1909, five in 1911, and seven in 1925. The herd released in 1909, in New Fortuna Bay, thrive well and have bred so as to now form a considerable stock. Their biological conditions are of considerable interest. Thus, for instance, it was found that the animals very soon after being moved from the northern to the southern hemisphere adapted themselves to the changed conditions. The

*'On the Geology and Physiography of some Antarctic and sub-Antarctic Islands.' Scientific Results of the Norw. Antarct. Exp.

†See Olstad: "Trekk av Sydishavets dyreliv," *Norsk Geografisk Tidsskrift*, vol. ii, 1929, p. 511; and, further, 'Rats and Reindeer in the Antarctic,' Scientific Results of the Norw. Antarct. Exp., No. 4, 1930.

animals who were let loose in 1909 already in 1911 had calves born to them in the period October–November, that is to say, in the Antarctic Spring, whilst in Norway calving takes place in May. It is estimated that the stock of animals now numbers several hundreds, not counting the many which have been shot and provided a welcome variation in diet at the stations.

We will now leave the season 1927–1928 and proceed to the next one. Consul Christensen had already at an early juncture decided that the *Norvegia*, after thorough repairs in South Georgia, should go on a new cruise in the season 1928–1929. As master there was appointed the former first officer on board, Nils Larsen, Captain Horntvedt having taken over the command of a floating factory. The practical objects of the expedition, in addition to seeking new whaling grounds, were to investigate whether the Thompson Island and the so-called "Chimneys" (some rocks reported by Norris) really existed, to endeavour to establish a wireless and meteorological station on Bouvet Island, to land on Peter I Island, and to search for Dougherty Island reported to lie at about 59° S. and 119° W. In addition oceanographical and other investigations were to be made. As leader of this work the expedition was joined by Dr. O. Olstad and as assistant E. R. Hansen of the Zoological Museum, Oslo.

The desirability of obtaining a meteorological station on Bouvet Island (or an island in that area) had been pointed out long ago by prominent meteorologists, and Consul Christensen spared nothing in his endeavours to realize the plan. By the floating factory *Thorshammer*, which left Sandefjord in October 1928, there were sent southwards to the *Norvegia* material for two houses, a large number of the necessary instruments, and material for a powerful short-wave wireless station. Three men accompanied the ship as staff for the station, two of them being wireless experts. The *Norvegia* left South Georgia on November 8 in order to meet the *Thorshammer*, and another of Christensen's floating factories, the *Pythia*, in the neighbourhood of Bouvet. The conditions in those eastern waters had changed since the previous season. The discovery by the first *Norvegia* expedition of large numbers of whales in the waters near and to the south of Bouvet Island had resulted in Christensen sending several whaling vessels to those waters, and also other whaling companies based their operations on those eastern waters in the season 1928–1929. Thus the first *Norvegia* expedition had already had extremely important practical results, and in reality both during the season in question and in the following ones an enormous number of whales were captured in those eastern waters.

On December 8 the *Norvegia* and *Thorshammer* met near Bouvet, and on the 10th they began in a high sea to transfer the material from the huge floating factory to the little *Norvegia*. The carcase of a whale was placed between the ships as a fender, but nevertheless the work of transfer was extremely difficult. The work was continued on the following day, but finally they were compelled to enter the pack-ice, which was not far distant, in order to find quieter water in which to continue. Later on a quantity of material was procured also from the *Pythia*. When the large ships were left and the *Norvegia* took her course towards Bouvet, the weather was particularly bad, with high seas and snowstorm, and the vessel shipped heavy seas on deck. It was known that the island was near, but nothing could be seen, and it was necessary therefore to lie to. On the 10th the weather improved and the island was visible,

so that land was approached. Several trawls were made in order to procure biological material. The spot was reached where a small depôt house had been erected by the former expedition, but all trace had disappeared. The sea had evidently carried away everything that had been put on shore. It was therefore certainly not a suitable place for a meteorological station. The possibility was then discussed of erecting the station on the quite low and small island at the south-west point of Bouvet, but the island is to a great extent washed over by the sea and there would also be a risk of running short of fresh water, since there was none on the island and furthermore no ice there. It was not possible to find any other suitable place, and the landing of material, which in itself would have been extremely difficult, had to be abandoned.

For some time after those on board were engaged in taking soundings, in zoological work, etc., until on December 21 they left the island to search for Thompson Island. These investigations were continued for more than a week, but without result, and it was concluded that a dark iceberg had probably been mistaken for an island. The weather at that time, including Christmas Eve, was extremely bad. At last investigations were abandoned and connection was established with the *Thorshammer* and the transport vessel *Thorøy*. The material for the wireless station was transferred to the former, while the three members of the staff went aboard the latter; and the *Norvegia* then proceeded westward with Peter I Island as her chief object. I will not here go into details, but will mention that after a voyage lasting from January 4 to February 1 the island came in sight, and on that occasion the first landing on the island took place. The first attempt nearly had fatal results, for the Captain, when jumping on shore, fell into the sea and was badly crushed between the cliff and the rowing-boat. However, a landing-place, somewhat better sheltered from the waves by ice, was found farther to the south on the west side of the island, and on February 2 the Norwegian flag waved on the rocky slope a short distance from the sea. A little hut was set up and equipped with various supplies. The following six days were spent in sounding around the island, in taking sketches, photographs, collecting specimens of rock, etc. The island has a markedly long and narrow shape with bare land mainly in the cliff on the west coast, and on the east coast in a steep mountain side which leads to the summit of the island. There is a remarkable shelf or platform in the surface on the west side, and it is rather probable that this platform has been cut by the sea and coastal glaciers during a lower level of the land-mass in relation to the level of the sea. At the present sea-level the breakers have also cut well into the island, as the cliffs tell us.

The course of the ship was then taken southwards, but impenetrable pack-ice was soon encountered, and the attempt to reach farther south had to be abandoned. The vessel continued westward until February 20, when it was at about 140° W., that is to say, nearer to New Zealand than to South America. On the return journey she went farther north, almost on a level with Cape Horn, with the object of seeking for Dougherty Island. Great efforts were made to find the island, but without result. In fact, nothing was observed which could signify the presence of land. It was not until March 19—that is, far in the antarctic autumn—that the *Norvegia* was again at South Shetland and the crew were at last able to spend some days in port at Deception Island.

On arrival she had no more than 20 tons of coal left. On March 30 the *Norvegia* was at South Georgia and was laid up for the winter. She had then been at sea for four months and twenty-two days.

We now come to the next season—that of 1929–1930.* The *Norvegia* expedition had then a character somewhat different from that of the two earlier ones, in that aviation formed an important part of its work. Consul Christensen engaged Captain Riiser-Larsen, the well-known companion of Roald Amundsen on his Arctic flight from Spitsbergen in 1925 and on his flight across the North Pole the following year in the airship *Norge*, and in addition Captain Lützow-Holm, another eminent airman, who, *inter alia*, took part in the search for the *Nobile* expedition on Spitsbergen in the summer 1928. A Lockheed Vega monoplane was purchased from America, and in addition there was sent southwards a little Hansa-Brandenburg monoplane (F.18), a seaplane, lent by the Norwegian Navy. The expedition was excellently equipped with suitable compasses, surveying instruments, wireless set, etc. Riiser-Larsen, who was to be the leader of the expedition, prepared himself for the oceanographical work which was to be carried out by studies at the Geophysical Institute in Bergen and by taking part in a short cruise in the research vessel of that Institute.

On August 24 the aeroplanes and gear were sent southward from Norway in the *Thorshammer* which also had Riiser-Larsen and two assistants aboard; Lützow-Holm followed somewhat later *via* Southampton and Cape Town, and on October 27 the *Thorshammer* met the *Norvegia* in the waters west of Bouvet Island. The *Norvegia* had then been to the island where already, at so early a date, there were considerable masses of ice. However the vessel got close to land at the north-west point (Cap de la Circoncision) and under great difficulties in landing there was erected a depôt house. The plan of a radio station had, after last season's experiences, been abandoned for the time being, and the equipment was placed by Christensen at the disposal of the Norwegian meteorological station in Myggbukten Bay on East Greenland.

On November 8 the *Norvegia* took the aviators and both aeroplanes on board, and then set out on its real cruise. Before trying to get south to the Antarctic continent, which was the main object of the expedition, endeavours were first to be made to take photographs of Bouvet Island from the air, and in the time November 12–14 several flights were made near and over the island. The clouds however were low so that it was not possible to take vertical pictures, but on the other hand a number of oblique photographs were obtained. The assumption made by the *Valdivia* expedition of a crater-like depression in the north-western part of the island was confirmed. A house was also erected on Lars Island.

The *Norvegia* then proceeded eastward along the edge of the pack-ice, which was still on a level with Bouvet Island. Riiser-Larsen chose to go far to the east before the actual penetration into the ice began. It was not until about December 1, north of Enderby Land, that the *Norvegia* began to work towards the land. At first progress was slow and the open spaces in the ice were far

*Cp. Hj. Riiser-Larsen, "Den tredje *Norvegia* ekspedisjon, 1929–1930," *Norsk Geografisk Tidsskrift*, vol. iii, 1930, p.241; and, further, "The *Norvegia* Antarctic Exp. of 1929–1930," *The Geographical Review*, vol. xx, 1930, p. 555.

between. Moreover her stock of coal had already greatly diminished. Later on progress was easier, and on December 5 there was a large area of open sea ahead, but there was soon again pack-ice at her bows. The vessel had now passed the 64th parallel, and on the 7th the airmen in the F.18 took surveys at a height of 1000 metres and saw land with high mountains to the south. They went southward for some distance, but then returned, after three hours' flight, to the *Norvegia*, as the wind was unfavourable and a long flight had not been planned.

A large lane running to the south-west had been seen west of the *Norvegia*, and the plan was to advance in it on the vessel. However they did not succeed, for the path was soon blocked, and there was a period of bad weather, wind, snow, and fog. It was not until December 21 that the *Norvegia* could penetrate to the south-west, and on the 22nd the airmen left on the F.18 with Enderby Land as their goal. They carried a heavy load of all kinds of equipment: tent, ski-sledge, skis, radio station with motor, etc.

It is evident that a long flight with a little ship in drifting ice as a basis is a very hazardous undertaking, since in the event of fog there is a risk of not finding the way back. On the tour southward therefore all characteristic icebergs were sketched on a map so that there would be definite landmarks for the return flight. After one hour and nineteen minutes they reached the edge of the inland ice, and after another twenty-five minutes' flight along the edge of the ice south-westward a landing was made in the open water from which it was possible to ascend a low sloping surface of ice. To the south-west there were seen bare, ice-free rock in several places, and the two airmen started off on skis in that direction in order to secure some specimens. However as soon as they had started a tiny cloud was observed over the inland ice, a circumstance which indicated that moist air was rising from the sea and that there might soon be fog. They continued however, but when after two hours' march they understood that there was still at least one hour's journey to the ice-free places, and that it was growing foggy also over the sea, they dared not continue, but returned to the machine. It had then become foggy on shore, but a short distance out the air was again clear. Course was set towards the point where they had left the *Norvegia*, and they soon recognized various icebergs and found their way to the vessel, which however was only visible through an opening in the fog.

The ship then went to the north-west, where progress was easier, in order to meet the *Thorshammer* and take in fresh supplies of coal. They then returned south-eastwards towards the coast in order to continue the work of investigating the coast-line farther to the south-west. On January 14 they met Sir Douglas Mawson's expedition on the *Discovery*, and paid a visit on board. On January 15 and 16 flights were taken towards the coast-line, which was sketched on a map. The land area in question, lying south-west of Enderby Land, was called Queen Maud Land after the Queen of Norway.

During this period the *Norvegia* had considerable difficulties, caused by sea and ice. The ship was deeply laden with coal, including that on deck, and during a storm a quantity of this coal was carried away by the sea. On the 17th and 18th the ship was in a very critical situation with great pressure by ice, but after more than twenty hours' hard work she was again clear of the ice.

The *Norvegia* then proceeded westwards, and during the cruise there was discovered, between 32° 11′ and 32° 38′ E., in about latitude 68° S., a bank with comparatively shallow water (600–800 m.). This shallow part was later on called the Gunnerus Bank.

They advanced westward, at times under difficult circumstances. The *Norvegia* had then sustained considerable damage to her bow and other parts, and leaked a good deal, and it was therefore with great relief that on February 16, at about 12° W., near the entrance to the Weddell Sea, they found open water which gave a passage southward, and two days afterwards the ship was close to the ice barrier. The F.18 was made clear and a flight taken south-westward along the edge of the ice. The flight lasted two hours, at times in fog, and the main features of the coast-line were sketched of the land, which has received the name Crownprincess Märtha Land, and which meets Coats Land to the south-west. No ice-free land was seen. On February 20 a new flight was taken with a more westerly point of departure.

Then followed days of rough weather with heavy storms; but these came from the land side so that there was no sea, but the spray blew over the ship so that when the wind lulled she was white with salt to the top of her masts. It was now late in the year, and in calm weather the sea began to be frozen so that it was time to proceed northwards. On March 2 the *Norvegia* again met the *Thorshammer* (at about 67° S., 12° E.), which vessel took the aeroplanes on board. After having taken in coal the course was set northwards, and on the 23rd the *Norvegia* was in Cape Town. There the cruise ended. About 370 nautical miles of coast-line had been mapped, mostly new land, between 43° and 55° E., and more than 200 miles of new land north-east of Coats Land. A large number of oceanographical stations had been taken in high latitudes and otherwise observations of many kinds made.

There now remains a short account of last year's voyage. Already, soon after the *Norvegia* was purchased, Christensen had thoughts of sending the vessel around the South Polar continent in order to make observations of the occurrence of whales and the food upon which they live, also regarding ice conditions in connection with other oceanographical investigations. This plan was realized in the last season with the well-known Arctic investigator, Major Gunnar Isachsen, as leader and Mr. J. K. Eggvin as specialist for oceanography.

The *Norvegia* left Cape Town on 4 October 1930, and ten days later passed Bouvet Island. On the 17th the ship took in fresh coal from the floating factory *Thor I* and then proceeded eastward to a position where a ship in the previous season had reported a rock. No rock was found, but, on the contrary, a depth of over 4000 metres, so it was evidently an iceberg which had been seen.

The voyage was continued eastward. At the beginning of November the stocks of coal were supplemented from the floating factory *Falk*. Coaling was very difficult in the swell, and in spite of every care the *Norvegia* sustained considerable damage to her bridge. One month later, not far from the Ross Sea, coal was again taken in, this time from the *Kosmos*. About the middle of December she was at the position where the Nimrod Islands have been stated to lie, but there also no land was found. Two weeks later the *Norvegia*

searched again for Dougherty Island, but no land was seen, and a number of soundings showed depths of between 4000 and 5000 metres.

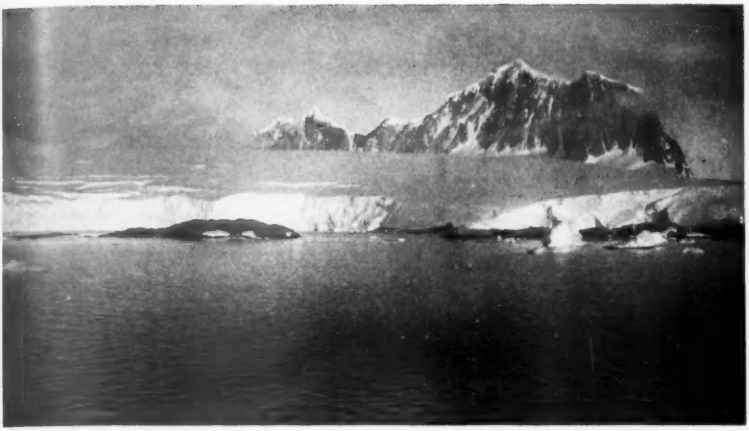
On January 2 they were so close to Peter I Island that they could see it, but a close belt of ice prevented the vessel from penetrating to the island, where it was intended to erect a house. One week later the *Norvegia* was in Deception Harbour, but, after coaling, at once continued to the east. She passed the South Sandwich Group on January 22 and was soon in the same longitude where she had been three and a half months before. The voyage was not thereby completed, because the *Norvegia* was then to be placed at the disposal of Captain Riiser-Larsen, who, with Consul and Fru Christensen, had travelled southward from Europe in the middle of December, and come south from Cape Town on the transport ship *Thorshavn*, which also carried the two aeroplanes which had been in the south the previous year.

The *Norvegia* met the *Thorshavn* on February 9, near the Gunnerus Bank, when Isachsen and Eggvin went on board the latter ship, whilst Riiser-Larsen took over the further leadership of the *Norvegia* expedition. Riiser-Larsen's companion of the previous season, Captain Lützow-Holm, had also travelled south in order to take part in the work of flying, but was taken seriously ill and remained in Cape Town.

The *Norvegia* then steamed south-westwards, and on February 16 and 17 Riiser-Larsen, with Captain Nils Larsen as observer, made two successful flights, and about 200 nautical miles of hitherto unknown coast-line, between 25° and 33° E., was mapped. The land was named after Princess Ragnhild, the daughter of the Norwegian Crown Prince and Princess. Also on February 21 and 23 flights were made. On account of the lateness of the season no further flights were attempted, and on February 25 the *Norvegia* handed over the aeroplanes to the floating factory *Thorshammer*. A few days later Riiser-Larsen went on board another steamer and Captain Nils Larsen assumed the command to take the *Norvegia* home to Sandefjord *via* Bouvet Island and Cape Town.

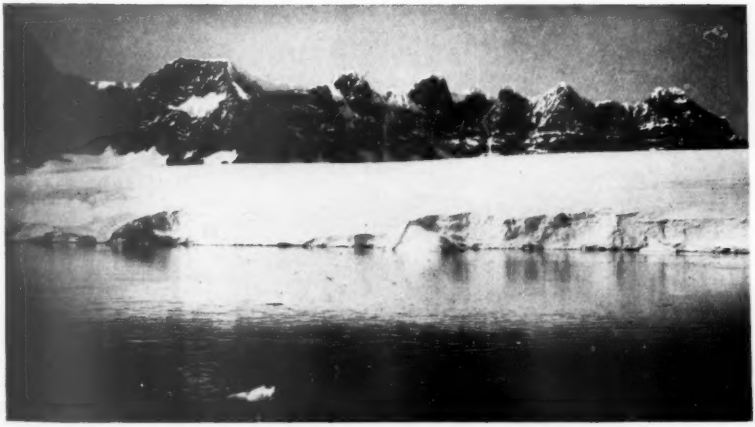
At first a search was made for the Pagoda Rocks, reported by Lieutenant Moore in 1845 at about 60° S. and 5° E., but not found since. At the position given the *Norvegia* sounded 5500 metres. On March 8 they were close to Bouvet Island in a hurricane which lasted for several days. They remained near the island for about a week, mostly in stormy weather, for the antarctic autumn was then far advanced. From the sea they observed that the house which had been erected the year before at the north-western point had been carried away by the sea. With great risk and difficulty the Captain succeeded in getting ashore on Lars Island at the south-west side, where also, as mentioned before, a house had been erected the previous season. This also had disappeared, and on the spot lay a mass of ice several tons in weight, undoubtedly thrown up by the sea.

In the last week of March the *Norvegia* was again at Cape Town, and on May 15 she anchored at Sandefjord, where the crew were given a fine reception. The captain, Nils Larsen, had taken part in all four expeditions: on the first occasion as mate, and on the last three as master of the *Norvegia*. The distance he had travelled in the little vessel during the four seasons, largely in the most stormy waters of the globe, corresponds to about two and a half times round the equator.



Wiencke Island, Palmer Archipelago

Brabant Island, Palmer Archipelago



Sierra du Fief Range, Wiencke Island

UNIV. OF MICH.

Strait between Bird Island (right) and South Georgia

South coast of Deception Island

North-west coast of Clarence Island, South Shetlands

Last season's *Norvegia* expedition performed very important oceanographical work. Over fifty stations were taken, more than one-half of which were to a depth of 2000 metres. Very extensive collections of samples (more than 2000) of water, plankton, etc., were made and are now distributed amongst the scientific laboratories at Oslo and Bergen. It is especially important that oceanographical observations have been taken in the Southern Pacific where previously very few investigations had been made. The new material will undoubtedly contribute towards our understanding of the circulation of currents in the largest area of water on the globe. Exact meteorological observations were of course also made throughout the voyage. Further, about 120 soundings, mostly in deep water, were taken.

I have mentioned that Consul and Fru Christensen went south in the last season, and on board the *Thorshavn* they reached very far south, in longitudes 70°–75° E. From the ship a large number of soundings were taken, and at latitudes about 66° 30′–67° 30′ comparatively shallow water (less than 600 metres) was found. This part of the sea-bottom was called the Fram-bank. The ice conditions at that time were extremely favourable, and there appeared to be chances for a whaler to penetrate right up to land in the waters east of Enderby Land. Christensen therefore requested the whaler *Torlyn* to try to reach land, and it succeeded in doing so. Under the command of Captain K. Mikkelsen the *Torlyn* approached close to the barrier on February 13 at 68° 50′ S. and 70° 28′ E. The following day they proceeded, at times between countless huge icebergs, west and north along the coast, which was there deeply indented in the form of a bay with a marked cape stretching north-eastwards on the west side of it. Continuing thereon westward they saw (between 66° 30′ E. and 65° E.) mountains in several places extending down to the sea, projecting above the inland ice. The coast-line in this area is, according to the positions given by Captain Mikkelsen, situated as much as 60–70 nautical miles south of the line drawn by Sir Douglas Mawson in his report on the *Discovery* Expedition 1929–1930 (see *Geographical Review*, vol. xx, no. 4, 1930). On the following day there was a snowstorm with rough sea and the course was set away from land.

In thus giving even a quite summary account of the expeditions during the five seasons there is no time to dwell upon the more special scientific results. These will be published by the Academy of Science in Oslo in a series of which hitherto six papers have appeared, of a zoological and geological character. A number of scientists are now working at the further studies of the material. The main results of course will be of an oceanographical character, comprising the physical, chemical, and biological conditions of the sea. In addition there will be reports on other zoological, on geological, and on meteorological results.

[In the absence of sufficient details we have not attempted to reconcile on the map the difference between Sir Douglas Mawson and Captain Mikkelsen, but have left the area blank for further inquiry.—Ed. *G.J.*]

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: It is possible that in the romance of Polar exploration the purely scientific part may be at times rather overlooked. It is therefore with particular pleasure that we welcome to-night Professor Holtedahl. He is a scientist and has spent much time in scientific exploration, both in the Arctic and in the Antarctic. There is an added pleasure in welcoming him because of the traditional friendship between all Scandinavian, particularly Norwegian, explorers in Polar regions and this Society, and as an instance of that we cordially welcome here the Norwegian Minister. Dr. Holtedahl is a Professor of Geology. He is no novice to Polar investigation. In 1909–10–11 he was at work in Spitsbergen, and since then he has been in Bear Island and also in Novaya Zemlya. The series of expeditions of which he will give an account to-night has been largely organized, instigated, and financed by Dr. Christensen, whom we also welcome here. Dr. Holtedahl is anxious that none should think that he personally has been on all the Antarctic voyages that he will describe. May I say that just prior to this meeting I read a message which came from Dr. Christensen, couched in language which is evidence of entire confidence between the man who wrote the message himself and those, ourselves, who received it. That creates a very delightful and pleasant atmosphere in which to listen to a lecture which I now ask Dr. Holtedahl to deliver.

Dr. Holtedahl then delivered the lecture printed above, and a discussion followed.

The PRESIDENT: Dr. Christensen is here, and though he told me this afternoon he could not speak English very well, I ask him to come forward, at any rate, and show himself.

CONSUL LARS CHRISTENSEN: Your President has been so kind as to mention my name in connection with the lecture to which we have just been listening. My interest in the Antarctic dates back more than twenty-five years when I first was interested in the whaling industry, and thus the primary object of the series of expeditions was to investigate various matters concerning, or related to, this industry. I thought however the expeditions should throw a fair amount of light on oceanographical conditions, geographical and otherwise, and the ships were equipped and manned accordingly. It is very gratifying to me to think that such a distinguished and important scientific institution as the Royal Geographical Society has found our work of sufficient interest to allow my friend Professor Holtedahl the opportunity of lecturing here to-night. For that honour, Mr. President, I tender you my sincere thanks and also thanks to all present to-night.

The PRESIDENT: All who are interested in the subject will have read in *The Times* that the *Discovery* came up the river a few days ago. I have pleasure in calling upon Dr. Kemp.

Dr. S. W. KEMP: I notice that Professor Holtedahl has been singularly modest with regard to the work that he has done. He has said a good deal about the magnificent flights made by Riiser-Larsen and a little about the oceanographical work which has been done by the *Norvegia*. He has not told you at all sufficiently what he himself has done. Now I have not until this moment had the pleasure of meeting Professor Holtedahl, but during the past two years a paper—I might almost say a book—that he has written on the sub-Antarctic Islands has been of the greatest value to us; in fact, the single copy we had on board the *Discovery II* is almost torn to shreds. It was very interesting to us to go over some of the ground that Professor Holtedahl has traversed, to read his account of the various islands and see how wonderfully he has interpreted the physiography and geo-

graphy of those parts. It is thus a great pleasure indeed to hear him speak to-night. Of course the part of his work in which we in the *Discovery II* are most interested is that relating to plankton and hydrology, in which we, too, have been doing a good deal. Mr. Rustad, whom Professor Holtedahl has mentioned, has published most valuable papers on Euphausians and Mysids, and I think probably other papers have appeared, but I have been back in England such a short time that it has not been possible to look them up yet. I hope that the work done by Major Isachsen and his colleague during their circumnavigation of the Antarctic continent will, in due course, give us some interesting hydrological results. Antarctic oceanography covers such an enormous field and presents such an infinite number of problems that we will always welcome any one who comes to help. It is to me a very great pleasure to find the *Norvegia* working down in those waters and carrying out similar investigations to those we are attempting. The problems are so intricate that I feel it is only by united endeavour that we can possibly reach a solution of the many questions waiting to be answered.

Mr. J. M. WORDIE: It gives me very great pleasure to say a few words in appreciation of the lecture which Professor Holtedahl has given. When I saw the photographs and, later, the cinema film showing the edge of the barrier and its surface features, it brought back memories in a very vivid way. I do not think any previous explorer in the Antarctic has taken such striking air photographs as those taken by Riiser-Larsen which we saw on the cinema film. They were most instructive and, together with the still photographs of the South Shetlands, form an important contribution to the glaciology of the Antarctic. Not the least interesting were the photographs illustrating Professor Holtedahl's own work, for he has made a suggestive advance in the study of Antarctic glaciers by formulating a new ice type, the foreland or "strandflat" glacier. In so doing he compares the one-time conditions in Norway with those in the Antarctic at the present day. A discovery like this shows how useful and important it is if a geologist has first been trained in a country formerly under glaciers before visiting still glaciated regions. Professor Holtedahl's work would also have lost a great deal of its value had it not been for his previous Arctic experience first in Spitsbergen, where his studies are well known, and later in the important expedition which he himself led to Novaya Zemlya.

The PRESIDENT: There is another speaker on whom I must call to-night, and in doing so I welcome a past-master in knowledge of all that has to do with Polar exploration and Polar regions, Dr. Mill.

Dr. H. R. MILL: I want you on this occasion to cast a retrospective eye over the history of Antarctic exploration, for it is interesting to recall how as the centuries pass the work recurs in waves of similar phase but very different amplitude. Amongst the names that look down on us in the gold lettering around the walls of this hall there are none more worthy of honour than those of the early Antarctic explorers who were connected with this Society—Weddell, Biscoe, and Ross, and so round the circle to Scott and Shackleton. Just over 100 years ago one of the Founders of this Society was Mr. Charles Enderby, an enlightened owner of whaling ships trading in Antarctic regions. I have met old men down the Thames who saw those little ships go out 120 years ago and who spoke of the excitement of their return with the news of the discoveries that had been made. This Society gave one of its very earliest Awards to one of Enderby's skippers, John Biscoe, who first, after Cook and Bellingshausen, made the circumnavigation of the Antarctic regions. It is interesting also to notice that Enderby endeavoured in the year 1850 to establish commercial whale fisheries in the Southern Hemisphere. The endeavour failed, but the work he did in promoting the scientific observations of his captains has survived. Enderby laid foundations which have

been built upon with conspicuous success by his spiritual successor, Consul Lars Christensen, who, with the immense resources and on the enormous scale appropriate to the twentieth century, has acted in the same spirit of scientific research which animated Enderby, and has spent a large portion of his resources in carrying on explorations, the scientific results of which will live in history long after the southern whale has become extinct or is only followed under conditions of humdrum commercial exploitation.

I have to express my great admiration of the modest and self-effacing manner in which Professor Holtedahl has described the work round the Antarctic regions, in which he has taken so conspicuous a part. It is appropriate and interesting that this Society, which received the earliest known record of Enderby Land and Graham Land, should now receive the latest information regarding these remote regions, and it does not diminish our pleasure in hearing the results of the *Norvegia's* cruise to know that our own old *Discovery* was down in those waters at the same time and has made similar and, no doubt, complementary observations. Together they will throw new light on that elusive land which some of us had almost feared was perhaps as mythical as the islands of Nimrod and Dougherty.

The PRESIDENT: Dr. Christensen and Dr. Holtedahl, how pleased that great compatriot of yours, Nansen, would have been to have heard the lecture to-night. I know that he gave you, my dear Professor, much encouragement many years ago. I know that you, as we all, have the greatest admiration for him, and also that you have acquired some of that great inspiration which Nansen was able to give to the world in many ways. He would have appreciated to the utmost extent the work which you have done. One thing he would have appreciated, and which we all do—immensely—and that is the readiness with which, encouraged by Dr. Christensen, you have given to the world the result of your investigations and research. You were so kind as to say that it was an honour to think that the investigations were of sufficient interest for you, Professor Holtedahl, to lecture here. Believe me, I am using no words of exaggeration when I say that it is a great honour to us to be the recipients of such invaluable information and knowledge as we have heard to-night.

I do not know whether I am prejudiced, but few, perhaps, except those who spend their lives at sea can realize altogether the difficulties which the people who go in small ships have to face when carrying out such investigations. The constant care, the courage, the endurance under great hardships which have to be brought to bear, the taking of all sorts of details, all that has to be gone through in times of very great difficulty, and also of great danger. Mark that only once has Dr. Holtedahl used the word "hazardous," and that was in regard to a matter which had to do with the air and not with ships. But we know perfectly well that many of the things that were undertaken were carried out in circumstances which were very hazardous. I am not in a position to discuss the matter from the scientific point of view, but I am in a position to render to you, Dr. Holtedahl, and to those who went with you, a word of the greatest possible admiration for all the work that you have done and for coming here to-night and telling us about it. You have heard from the men who are well qualified to speak what they think of your work. It only remains for me to add for myself and on behalf of this audience and the Society our most hearty thanks and whole-hearted admiration for your invaluable and excellent work.

THE PHYSIOGRAPHY OF THE WESTERN MACDONNELL RANGES, CENTRAL AUSTRALIA

C. T. MADIGAN

THE maps of Central Australia are very incomplete. The only precise work is that of the railway survey, practically along the telegraph route. The fullest use has not been made of the explorers' maps, though most of their work has been incorporated. The territory is now controlled by the Home Affairs Department of the Commonwealth Government, and only two maps are supplied by the Department: one a "General Map of North and Central Australia," 1927, in one sheet measuring about 4 feet by 2 feet on a scale of 24 miles to the inch, showing pastoral leases in colour, and isohyets, and another in two sheets, one of Central Australia and one of North Australia, as the Commonwealth subdivided the old Northern Territory, on a scale of 16 miles to the inch and dated 1926. Both contain the same geographical features, and both are poorly printed, with frequent gaps in lettering and lines. Owing to the gold bounty, and also to the times of depression, prospecting in the territory has been stimulated, though it never ceases at any time. The lack of maps is much felt at present. This was brought home by the complaints of the recently lost aviators and of a prospecting party and their searchers, in the region west of Alice Springs. The search for missing airmen is becoming very expensive to the Royal Australian Air Force, not to say dangerous to themselves.

The map issued by the Department of Home Affairs, Canberra, to a scale of 16 miles to the inch, is obviously compiled from Winnecke's and Chewings's maps, with additions from Giles's and others. Haast Bluff is shown about 13 miles too far west, which is the greatest error in the map. The remainder are of omission rather than commission. The Arumbera Creek is not shown, and the courses of the Davenport and Ormiston are very rough. Ellery Creek appears as a fan-like network. The main creek is not shown, nor any features in the ranges between the Finke and the Hugh. There is no attempt made to depict the ranges, but of course it does not purport to be a topographical map. On both occasions in the neighbourhood of Mount Ertwa I was unable to find any hill in the vicinity. It must be a high point in the range well to the north of its marked position in the Emily Plain.

The map and notes recorded in this paper are the results of three expeditions into the Western MacDonnell ranges, by motor car, aeroplane, and camel respectively, in 1927, 1928, and 1930. The object was primarily geology, but as errors and omissions in the maps were soon noticed, careful route surveying was carried out on all journeys, a lot of trouble taken with the aneroid, and in addition over 160 miles of aerial mosaic photograph obtained, so that the geographical work may merit separate consideration.

The first journey was made with Sir Douglas Mawson in 1927 by motor car from Alice Springs to Glen Helen to inspect an occurrence of potassium nitrate in limestone. It was the first and only motor car to follow the route shown on the map, which is the horse and stock track to Glen Helen Station. I do not advise any one else to attempt it. This was a very hurried visit, and the total time spent in the field was only five days. Some geological notes were

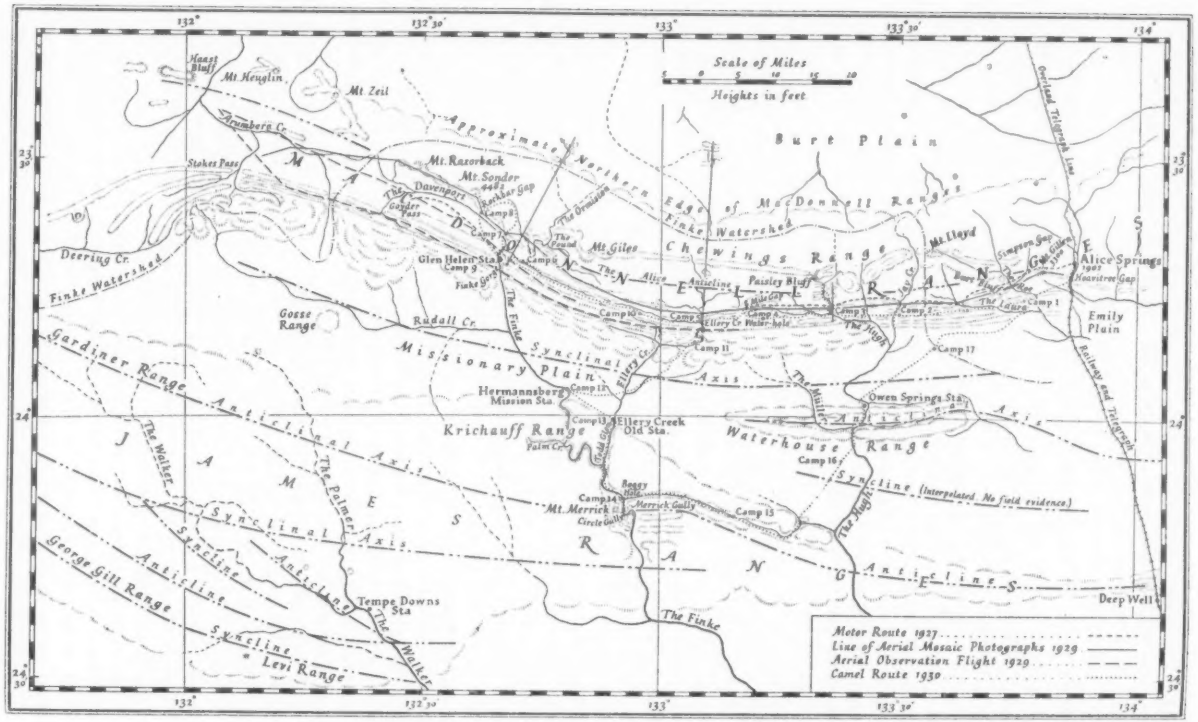


Fig. 1. The Western MacDonnell Ranges, Central Australia

made, and the trip served as a reconnaissance, and an inspiration to further work. Sir Douglas Mawson wrote a paper in our joint names.*

In August 1928 I made an aerial reconnaissance into this area under the auspices of the Royal Geographical Society of Australasia, South Australian Branch, with two aeroplanes lent by the Royal Australian Air Force. The main object of this expedition was a survey of the unknown south-eastern portion of Central Australia, but important secondary considerations were the investigation of the great salt lakes and an examination from the air of the Western MacDonnell Ranges. The results of work in the unknown area and on the lakes have been published.† The remainder is incorporated in this paper.

It was most important to the geology of this area to identify the ridges at the various points where sections across the ranges had been attempted, so that I made this my chief objective with the aeroplane. An Eagle camera for vertical mosaic photography had been sent to Alice Springs by rail for this special purpose. The length of film that could be carried made this camera scarcely worth while on our main 500-mile flights, and in any case the personnel of three in each plane, thought necessary by the Air Force, made it impossible except for special flights from a base. There were only two magazines available, which would each photograph a strip a mile wide by 80 miles long from 10,000 feet, so I decided to photograph a strip west from the Heavitree Gap to Stokes Pass, and then take three cross-sections: one at the Finke Gorge, one at Ellery Creek, and one at the Hugh. I was not able to fly in the plane with the camera, as only the pilot, Flying Officer Gerrand, and camera operator, H. Thomas, could get in with it. I instructed the pilot to stick to the Heavitree Ridge at all costs, which he did till it petered out at Mount Razorback, and then he took a course across the Glen Helen Valley towards Stokes Pass. He made the sections in the correct places, but in each case stopped short of the southerly margin of the ranges, in the most interesting area, and gave me rather more than I wanted of the plains to the north. He used all the film and made an excellent job of it, and for all he or I knew at the time the northern ends of the sections might have been more important than the southern. The overlap was constant and there was no gap in the whole 160 miles.

The same day I flew over this area in the other machine with Flying Officer Wight and got a general idea of the whole outlay of the ranges to the west of Alice Springs, with a good collection of oblique photographs. These latter, taken by hand, are a great help in sketching in detail, but exact measurements cannot be taken from them, as can be done with the verticals. Thus in two and a half hours I saw all and more of the topography than had been possible to Giles, Chewings, and Winnecke in weeks of toil.

The verticals, 7 inches by 7 inches, were mounted for me in strips by the Royal Australian Air Force. This main line I made the basis of my map. I had no ground controls other than the points plotted on the Canberra map. Mount Gillen, all the streams and gaps across the Heavitree Range, Burt Bluff,

*Mawson and Madigan, "Pre-Ordovician Rocks of the MacDonnell Ranges," *Q.C.G.S.*, vol. lxxxvi, 1930.

†C. T. Madigan, "An Aerial Reconnaissance into the South-Eastern Portion of Central Australia," *Proc. R.G.S. of Australasia, South Australian Branch*, vol. xxx, Session 1928–9; C. T. Madigan, "Lake Eyre, South Australia," *G.J.*, vol. 76, 1930.

Fig. 1. The Western MacDonnell Ranges, Central Australia

Mount Razorback, and Mount Sonder, were all easily identified on the strip photograph, but I soon found that I could not rely on the relative positions of these on the map, in order to arrive at a scale. The scale can be calculated readily from the height and focal length of lens, but the absolute height above the ground was uncertain, the reading of the altimeter having only a relative value. This reading is photographically recorded on every exposure, and it was kept constant by the pilot, so that one scale suited the whole series. After trying several points and comparing scaled distances to a trial scale with camel traverse distances taken later, I decided to take the position of Mount Sonder, one of the most distant and definite peaks, as correct on the Canberra map. From the map positions of Mount Gillen and Mount Sonder the scale and orientation of the strip mosaic were arrived at by ruling a traverse off on all the separate strips and plotting to a trial scale. This traverse is shown as the course of the aerial photographs on the map. Had Mount Sonder been fixed by triangulation, this traverse would be very reliable. The Mount Sonder position however if not correct is not more than a mile out in 80 miles, and the scale only of the map in the neighbourhood of the aerial photographs is affected. The scale of the aerial photographs was 1 mile = 5·89 inches, for which scales to read to one-tenth of a mile and 200 yards were constructed.

In May and June 1930 I was able to go over a good deal of the ground by camel, through the financial assistance of the Council for Scientific and Industrial Research, and the help of the Department of Home Affairs, through whom I obtained the loan of police camels from Alice Springs. The aeroplane is unsurpassed for rapid reconnaissance, but for any detailed work in this country it, the motor car, and the horse must all give way to that most primitive means of transport in the desert, unresponsive, repulsive, aloof, slow, safe, and certain—the camel in his natural environment. Time must be measured in days instead of hours, but when studying rocks which have lain there for five hundred million years, one begins to feel that a week one way or the other does not matter so much after all. In this journey of a month I was accompanied by Mr. E. A. Rudd, a geological student from the University, a black boy, and six camels; not that camels are ever much company. Their bells in the still, cool night are the most attractive thing about them.

Although I was, since the aerial survey, satisfied about the position and continuity of the Heavitree Range, the other ridges were still a little indefinite, and I determined to follow them west. There are four distinct quartzite ranges south of Alice Springs, with flat valleys between. The first and most imposing is the Heavitree Range. Between it and the next south lies the Police Paddock, followed by the Racecourse. The fourth ridge, south of the Racecourse ridge, is there low and inconspicuous. We first followed the only road west, the Mission road, a good motor track. There are only two places in occupation between Alice Springs and Western Australia, the Mission Station and Glen Helen Station. This track took us through No. 2 Quartzite Range at Temple Bar Gap (this name is used for both gaps formed by the Roe, in the Heavitree Range and in No. 2 Ridge). The Mission road then passes out into the plain south of the MacDonnells, the Missionary Plain, and continues in it to the Mission Station. We left this track at this Gap and went west between Nos. 2 and 3 Quartzite, never leaving them till we reached the Finke Gorge. Geological

The Pound, near Finke Gorge and junction of Ormiston and Pioneer Creeks *Phot. R.A.A.F.*

UNIV. OF RICH.

Looking north-east over the Finke Gorge

Phot. R.A.A.F.

cross-sections were made at the Jay, the Hugh, and Ellery Creek. This was the first time this valley had been traversed from end to end, including Wild Horse Plain, the very rough and scrubby area at the divide between the Hugh and Ellery Creek watersheds. There is no track. The track to Glen Helen lies on the north side of the Heavitree Quartzite up to the 8 Mile Gap through which it passes into the valley we were following, the Glen Helen Valley. This is the track taken on the first excursion by motor car. From Glen Helen we passed north-west through Gunpowder Gap in the Heavitree Range, into the rough granite country, west to Mount Sonder, and back through Rockbar Gap to Glen Helen. Thence we returned on our tracks along the north side of No. 3 Quartzite Ridge to Ellery Creek, and proceeded with the geological section down the creek till we reached the Missionary Plain again. We visited the Mission Station and then returned to Ellery Creek and followed it down in the James Range to Boggy Hole. After examining the remarkable amphitheatre there (Circle Gully) we went east up Boggy Hole Creek, out through a gap in the range, across the plain to the Hugh and Waterhouse Range (Stuart's original route), and from the Waterhouse Range across the Missionary Plain again north-east to the main range, through Temple Bar Gap and Police Paddock to Alice Springs. We crossed the Mission road in the plain in the dark and missed it. Apparently the camels did not notice it either. We were hurrying back and doing a long night march, having rather a bad time in the dead mulga of the plain, and wanted to find the track We must have camped a mile or two beyond it. I did not see enough of this track to put it on the map. Tempe Downs, Ellery Creek Old Station, and Owen Springs are now abandoned. New ground was broken between Temple Bar Gap and Ellery Creek, and in the journey eastward from Boggy Hole, in the James Range. No geological work had previously been done in the Waterhouse Range. The camel traverse is shown on the map.

As mentioned above, the aerial mosaic formed the basis of the map. The camel traverse was next plotted, corrected by the aerial points. The features outside the range of these traverses were drawn in after long and careful study of oblique aerial photographs, and Winnecke's, Chewings's, and the Canberra maps. The telegraph line, Alice Springs, and features in the neighbourhood, the hills north of the range conventionally drawn, Mount Lloyd, Mount Zeil, Mount Heuglin, and Mount Sonder come from the Canberra map, and are in agreement with Winnecke. Haast Bluff is from Winnecke, my own observations agreeing. Its position on the Canberra map is 13 miles farther west, obviously from Chewings. I took an aerial photograph of it, and was much concerned at the time as to my own position in the air, as I was using the Canberra map. The Mission Station is from Winnecke's latitude, and a bearing to Mount Sonder. This has moved the Station and Finke River to the south of it about 3 miles east from the Canberra map. Gosse Range was sighted from the aeroplane, but the whole of the remainder of the south-western portion of the map is a combination of Winnecke's positions and Chewings's detail (somewhat reduced), and was unvisited by me.

The general topography has been discussed in the results of the Horn Expedition, under "Physical Geography," in which the broad features have been well described, and the aim of this paper is mainly to correct and add new

Looking north-east over the Finke Gorge

features to the topographical map and to give new details, the chief of which is the delineation of the separate ridges in the ranges, on account of their important bearing on the geology, and for correlation of geological sections. However, as the Horn Expedition results are long out of print, and in order to make the detail clearer, a short general description will be useful. The area is near the centre of Australia, between 23° and 25° S. latitude, and 132° and 134° E. longitude. The rainfall is 14 inches, and the climate subtropical arid. The MacDonnell Ranges form a remarkable feature, a narrow east-and-west mass of high mountains, up to 5000 feet, rising out of desert plains. They cover an area about 250 miles long, east and west, by 20 miles wide, extending westerly from Alice Springs some 160 miles and easterly 90 miles. To the west they run in a series of remarkably narrow, high, and continuous parallel ridges, with flat and comparatively level narrow plains between. The ridges are all of quartzite, the valleys or plains representing limestone or slate beds. The most novel feature about these ridges is that they are absolutely uncrossable, even on foot, for distances of 30 miles or more, but they are intersected at right angles by the streams which pass through them in steep gorges known as gaps, which are now mostly named. The torrents which surge through the constricted gaps in the rains scour out deep and permanent pools, so that many of the gaps are impassable except by swimming, and by contrast with the usually hot weather the water seems icy cold. Simpson, Ellery Creek, Finke Gorge Gaps, and Redbank Gorge are always thus. They make permanent waters for stock. The Finke Gorge and Redbank Gorge are figured in the Horn Expedition narrative.

The Finke Gorge is becoming better known since the railway was completed, as several parties of tourists have been taken out to the Mission and up the Finke to the Gorge on a track recently made by native labour. The tourists may converse across 100 yards of water with old Mr. Raggatt, of Glen Helen, if he deigns to answer, but if they want to visit him it is a 40-mile journey by Goyder Pass to the west, or a 60-mile journey through Ellery Creek to the east, by camel or horse. Mr. Raggatt has been there forty years, and says the place is becoming too civilized, and he must move farther out. Some one shot one of his black swans, and in future he intends to shoot back if he hears any firing.

To the east of Alice Springs the ranges soon become much more broken up, trending north-easterly and merging into jumbled hills without the regular arrangement of the west. North of the main ranges lies desert, with isolated hills, called the Burt Plain, near the telegraph line. South of the main ranges is the long, narrow Missionary Plain, 150 miles long by 20 miles wide, called the Emily Plain near the telegraph line. The next physiographical feature south is the James and Waterhouse Ranges, and south of them again, the sandy and stony plains of the Lake Eyre Basin. The Finke watershed has been delineated on the map. Its drainage basin includes nearly the whole of the Western MacDonnells and the James Ranges. The Hugh, Ellery Creek, the Ormiston, Davenport, Rudall Creek, the Palmer and the Walker, all join the Finke, which loses itself in the desert in the region north of Lake Eyre. According to Dr. Jack, a big proportion of these waters finds its way into the Great Artesian Basin. The rivers to the east of this watershed are lost in the Great Ribbed Desert, and to the north they also fade out in desert.

The MacDonnell Ranges

Only the portion of the ranges appearing on the map, that is, west of the telegraph line, is here dealt with. Geologically the rocks of the ranges fall into four divisions: first, ancient crystalline rocks, gneisses, gneissic granite, granite, and minor intrusions, granite rock preponderating to the west—this I will refer to here as the Archaeozoic division; second, a younger sedimentary series consisting of quartzites, limestones, sandstones, and shales, of great thickness, referred to as Proterozoic; third, Ordovician rocks, mainly quartzites and sandstones, fossiliferous in part; and fourth, the post-Ordovician conglomerate. To understand the physiography of the region, these four divisions must be recognized.

The most conspicuous ridge in the ranges is the Heavitree Range. It stands majestically as a barrier across the way as one approaches in the train, and it contains most of the high peaks. It consists of quartzite, vertical or dipping south, and is almost continuous from Heavitree Gap to Mount Razorback, being slightly displaced by faults here and there. It is carefully plotted on the map from aerial photographs. This ridge forms the southerly limb of an anticlinal fold which is noticeable from the ground near Alice Springs, but very much more conspicuous from the air. The northern limb starts a few miles west of the telegraph line. Simpson Gap is in it. It runs parallel to the Heavitree Range, but is less regular. At the Hugh it breaks into a triangular mass of jumbled hills, and then reforms at Paisley Bluff and runs for 40 miles west as a very conspicuous range, to the Ormiston, where it closes in to meet the Heavitree Range. At this point a pound is formed—a most interesting feature. This pound is open to the east only. The width of the opening was hard to estimate. It may be narrower than the map shows. It appears to be completely closed in the aerial photograph, but the view from the summit of Mount Sonder was quite different. Mount Giles is in the neighbourhood of this pound, and I have definitely attached the name to the peak in the angle where the northern range comes closest in to the Heavitree Range, before opening out to form the pound and closing again at the Ormiston. Thus the Heavitree and this range are outcrops of an eroded anticlinal fold pitching west and gaping to the east. Chewings recognized that the northern range and the Heavitree Range met near Mount Giles, and I have attached his name to this important feature, the counterpart of the Heavitree Range, where I hope it will stick better than in the case of Winnecke's attempt to honour him with Mount Chewings. This anticline is the key to the structure of this portion of the area. Between the two outcrops, steep ridges rising to 2000 feet above the general level, lies rough, rugged gneissic country, which appears flat from the air. Alice Springs lies in this area. I have marked in the axis of the fold, which I have called the Alice Anticline. North of the northern quartzite limb, the Chewings Range, lies a similar area of gneiss and schists, 5 to 10 miles wide, extending to the northern border of the ranges, where there is a steep fall to the plains. This border is sketched in, only two points in it being fixed by the aerial cross-sections. The streams mapped by Winnecke are a guide. There are no distinct peaks, or definite formation, in this area, which is very rough and dissected by innumerable small watercourses. The Heavitree Range may be crossed in eight places between Heavitree Gap and Ellery Creek, a

distance of 50 miles, but is impassable for the next 30 miles to Gunpowder Gap.

A single quartzite ridge continues west from the pound at the Ormiston to Mount Sonder, where a second anticlinal structure is seen. Mount Sonder is a crescent jutting out in a north-easterly direction from the main ridge. It consists of a quartzite capping on granite. The dip of the quartzite is in a radial direction from the centre of the crescent, being north on the north side, west on the west, and south on the south side. The structure is the same in miniature as that of the Pound. The fold had died out and then reappeared. A single ridge continues again westerly to Mount Razorback, after which it dies down. It might be possible to trace the quartzite farther on the ground, but not from the air. Farther west the same quartzite is found capping the mountains, but the general level of the country is now falling. Anticlinal structure is still shown by the quartzite capping to the north on Haast Bluff, where it dips north and to the south on the unnamed ridges along the Arumbera and south of Haast Bluff. The quartzite was plain on Haast Bluff from the air, but Mounts Zeil and Heuglin appeared to be of gneiss, which Chewings states to be the case. These points were probably once capped by quartzite, which has been removed by erosion.

South of the Heavitree Range there are three quartzite ridges seen near Alice Springs, referred to as No. 2, No. 3, and No. 4 quartzites, following Dr. Ward's geological section along the telegraph line.* These run almost parallel to the Heavitree Range, and absolutely parallel to each other, for over 100 miles to the west, in a most extraordinarily regular formation. They do not rise to the majestic heights of the Heavitree Range, but are at a general height of from 200 to 400 feet above their surroundings. Between the ridges run valleys, timbered with mulga. These are narrow plains rather than valleys, as their floors are flat and the ridges rise steeply from them.

It was the mapping and identification of these remarkable ridges and valleys that was our primary object. The Horn Expedition appears to have recognized one main valley only, which they called Horn Valley. This series is mainly the second geological division referred to, the Proterozoic. The quartzite of the ridges, and limestone and shale of the valleys, which everywhere back up the Heavitree Quartzite to the south, are not repeated on the north side of the Alice Anticline. They run parallel to the Heavitree Range, but do not share in all its bends, as evidenced by their being chords to the arc of which Mount Gillen is the centre. They show no faulting, whereas the Heavitree Range is displaced in several localities, very notably at the Jay Creek. No. 2 Quartzite, so conspicuous as a southern boundary to the Police Paddock, gradually dies away towards Jay Creek, beyond which it could not be seen from the air, but was traced on the ground to beyond the Finke, in small ridges up to 50 feet high. No. 3 Quartzite, everywhere of a characteristic dark red colour, distinguishing it from all other ridges, continues of uniform appearance and height, except where cut down by the transverse streams, to Goyder Pass, beyond which it was not traced. It cannot be further seen from the air at the usual cruising height of not less than 2000 feet, which gives a small enough margin of safety

*L. K. Ward, "Notes on the Geological Structure of Central Australia," *Trans. Royal Society of South Australia*, vol. xlix, 1925.

in such rugged country. One very lucky forced landing was made in the Eastern Ranges.

Thus, west of the Jay, the Racecourse and Police Paddock valleys become one. West of the Ormiston the Heavitree Range trends more northerly, away from No. 3 Quartzite, and the valley opens out from 1 mile to 6 miles in width at Mount Razorback, after which the northern wall becomes less well defined, and the Arumbera runs in a broad plain. This valley I have called the Glen Helen Valley. It starts as two valleys, the Police Paddock and Racecourse, but after the Jay Creek it is one feature lying between the Heavitree Range and No. 3 Quartzite, for 100 miles. This was the first time it had been completely traversed.

Next south follows another valley, never more than a mile wide, and averaging half a mile, lying between No. 3 and No. 4 Quartzite Ridges. This is the most regular and uniform of the valleys, and is well defined from the telegraph line to Goyder Pass, a distance of 90 miles. Being narrower, it is probably difficult to travel in, though open enough at the Jay, Ellery Creek, and Glen Helen.

No. 4 Quartzite is the first bed in the No. 3 geological division. It ushers in the Ordovician series of beds, mainly quartzite and sandstones, with some thin fossiliferous limestones. The series is steeply dipping where first met with, but it extends in folds far to the south, the same beds appearing again and again in the James Ranges. The series first appears as a single quartzite range, No. 4 Quartzite, near the telegraph line, where it is low and inconspicuous, but it soon increases in height and importance, being very imposing between the Laura and the Hugh, standing boldly out from the Plain, and being easily mistaken for the main range, which it obscures, from the Mission road. Mount Ertwa is probably a peak in this portion, being marked too far south on the Canberra map. There is one very characteristic and remarkable feature about this quartzite, which makes it recognizable from a distance anywhere. It is invariably crossed by small grooves or valleys at regular distances apart, giving it the appearance of a saw edge with rounded teeth. The valleys have only cut down about one-third of the height of the ridge. This is a feature not shared by other quartzites. To distinguish this quartzite on the map, little curves have been drawn in it, which suggest its appearance in elevation. It is seen in the Waterhouse Range, and from Mount Merrick eastward in Boggy Hole Valley.

West of the Hugh the quartzite is again low, but soon regains huge proportions, being a mile wide at Ellery Creek, and a mile and a half at the Finke Gorge, as more beds are exposed in the series. There are really three main quartzites in the series, the last being softer, redder, and more of a sandstone. It is the quartzites which stand out and make the features, the limestone and shale (of which there is very little) tending to form valleys. Between the first and second quartzites lies the narrow fossiliferous limestone, and this limestone forms the real Horn Valley, which is defined by the occurrence of Ordovician fossils, and wrongly located in various places in the Horn narrative. In the narrower, eastern end of this formation it has the appearance of a single range, but at Ellery Creek two valleys have developed in it, the Horn Valley and another south of the Horn Valley and extending back east, probably not more

than a mile or so, closed to the west. The Horn Valley is here only a cleft in the quartzite range. By going either east or west one soon mounts up its stony narrow floor till the valley is only a slight depression in the high range. From the Finke Gorge west however it is eroded down almost to the level of the Finke, and is a narrow traversable gully, as described by the Horn Expedition, who travelled in it from Goyder Pass to the Finke.

From Stokes Pass west the formation is still a little indefinite. There is some grand scenery here, as described by Giles and Winnecke. I did not visit the locality on foot, and had only a rather distant aerial view. The formation widens out and takes a southerly curve. Three distinct ranges are seen, as shown on my map and also by Winnecke. They correspond to the three chief quartzites in No. 4 division. Their positions are only sketched in. The more northerly range extends somewhat beyond the limits of the map. Between Stokes Pass and Deering (or Carmichael) Creek is probably the highest point in the Finke Watershed, excepting mountain peaks. The dip of the beds has here flattened out, widening the outcrop of the formations, and causing very abrupt escarpment on the northerly side of each ridge, particularly the most southerly, Mereenie Escarpment. Information about this westerly end of my No. 3 geological division in Ordovician rocks is meagre, and my aerial photograph is not clear enough for reproduction.

No. 4 division is totally different from the previous formations. It is composed of the Post-Ordovician conglomerate, a coarse "pudding-stone," and forms an irregular margin of hills on the south side of the Ordovicians. It is the southern margin of the MacDonnell Ranges. These hills, unlike the severe ridges of the main ranges, are rounded, with no regular formation, the beds being cut up by a network of watercourses. They make a most obvious feature from the air, appearing quite white, owing to being covered with pebbles and boulders of gneiss and granite of a light colour.

They are unknown east of the Hugh, but are continuous west to the Mereenie Escarpment, in an irregular strip from 2 to 5 inches wide. A triangle stretches south from Goyder Pass, a conspicuous feature from the air, its apex extending towards Gosse Range. At the western end they are higher than the ridges of No. 3 division, but east of the Finke they appear as foothills to the main range. Towards the Hugh they encroach on and finally swamp the No. 4 Quartzite, wiping out the Horn Valley. The Müller has its source in them, also Rudall Creek, and the tributaries of Ellery Creek. The main stream of Ellery Creek cuts right through the ranges, a point not shown on the Canberra map.

The Missionary Plain occupies a syncline, an alluvial flat covered with mulga, well grassed after rains. Gosse Range is an isolated mass of hills, of apparently circular outline, probably a remnant of the conglomerate. Its position is approximately correct. Giles's is the only written record of a visit to it, and all rocks were much the same to him.

The James Range

The No. 4 division of rocks, the Ordovician, appear again south of the Missionary Plain, in the James and Waterhouse Ranges. The northern border of the James Ranges was fixed by me in two places only. The remainder of its limits were sketched in from the maps of all other explorers, and is only

approximate. Gardiner, Krichauff, George Gill, and Levi Ranges are only units in the James Ranges, which peter out in desert just west of the limits of my map, and narrow down at Deep Well on the telegraph line. They make again to the east, as shown in my map of that country from the aerial reconnaissance. The James Ranges reach heights of 2400 feet above sea-level, but are nowhere as imposing as the MacDonnells. The main anticline was located on the Finke at Mount Merrick, the axis lying along Merrick Gully. I also established the anticlinal axis of the Waterhouse Range, but all the other fold axes in the James Range were taken from the work of Chewings and the Horn Expedition. The latter spent considerable time in the neighbourhood of Tempe Downs, which was then occupied.

The meanders of the Finke, as shown on the Canberra map, are much exaggerated. I only traversed the portion between Ellery Creek and Boggy Hole, where I found there was no relation between the actual curves and the map. These meanders seem to have been sketched in conventionally. Winnecke traversed the Finke from the Mission Station down to Palm Creek, and I have copied his plan for this portion, cutting out the exaggerated meanders of the Canberra map. The portion between Palm Creek and Ellery Creek is probably far from a true representation of the curves. Giles first sketched in these extreme windings. Winnecke straightened them out a lot. One has to travel right in the stony bed of the river, and it is very difficult to keep a tally on the bends. One is busy enough keeping one's animals on their feet. Chewings's meanders are like Giles's.

The Finke and Ellery Creek courses in the James Ranges are most picturesque and call for much admiration from all travellers. The creek beds are mostly wide and stony, and bounded by red perpendicular walls of sandstone rising several hundred feet. Large eucalyptus cluster in them, and the dark green of these trees makes a beautiful effect against the bright red walls. For long distances it is impossible to get out of the glens, quite the reverse from the same streams in the MacDonnells, where they flow through flat plains, separated by the remarkable narrow clefts in the ranges. Those strange and isolated palms, *Livistona Mariae*, are found in the Finke, but not in Todd Glen or below its junction with the Finke.

The majority of the James Range is formed of red sandstone, the topmost bed of the No. 4, Ordovician, division. It is only along the axis of the folds that erosion has exposed the lower beds and fossiliferous horizon. I was told of Circle Gully by the people at the Mission Station, as an interesting place worth visiting, and as it seemed little known and was undescribed I thought it might bring forth something new. My homeward route, chosen on their advice, proved a most happy choice.

Circle Gully is the bend in the Finke at Mount Merrick. The Mount is on the axis of the anticline and rises 600 feet above the river bed. The outcrops from the east meet here, just as the quartzites in the MacDonnells do at the pound, the fold pitching west. The saw-edge quartzites form the ridges east from Mount Merrick, the higher red sandstones lying to the west of its meridian and everywhere flanking the quartzites, whose outcrops meet in a semi-circular curve at Mount Merrick. The aerial photograph of Circle Gully was taken by the MacKay prospecting expedition, and given to me by courtesy of *The*

Australasian, Melbourne, who first published it. The photograph from the ground is my own. This is a very fine example of the erosion of a pitching anticline, apart from the scenic wonders of the spot.

Boggy Hole is one of the permanent waters of the Finke. I followed up Boggy Creek eastward from Boggy Hole. The valley of this creek corresponds exactly to the Horn Valley. Its floor is the fossiliferous limestone and its sides the impassable quartzite barriers. This was a new locality for this limestone.

The Waterhouse Range is another eroded anticline, and the section the Hugh makes through it is most important geologically. It had so far escaped the prying hammer of the geologist. The axis of the anticline, the core of the range, is a comparatively level area, enclosed by the saw-edge quartzites which rise several hundred feet above the plain. Here erosion has gone deeper and exposed in the centre the underlying cryptozoon limestone of Division 2, the Proterozoic Rocks.

In structure the area is thus seen to be a series of eroded folds with east–west axes. The ranges are the limbs of folds near anticlinal axes, the plains are filled synclinal troughs. The main MacDonnell Range is an ancient geo-syncline, which has not subsided beneath the seas since at least early Palaeozoic times. Its major rises and falls took place in pre-Cambrian times, when the Division 1 and 2 rocks were formed. Since the close of the deposition of Division 2 the ranges have remained on elevation, never completely levelled. Division 3 rocks were deposited on the south side only. The great conglomerates of Division 4 were formed by southward-flowing torrential streams, which carried out immense erosion. The country to the south was invaded by Permocarboniferous and Cretareous seas, both carrying icebergs, but the old ranges remained dry land, with a southerly drainage system. In later Palaeozoic times there were isostatic readjustments as erosion went on, and east–west folding continued, buckling the formations to the south. The ancient rocks to the north of the ranges are almost horizontal and have remained practically undisturbed since Cambrian times. It is possible that the folding to the south continued into Tertiary times, but it did not extend into the Mesozoic beds of the great Artesian Basin, which lies to the south of the James Range. This folding must be in part due to the marginal effects of the epeirogenic movements of subsidence and elevation which admitted and drained away the Permocarboniferous and Cretareous seas. The rivers are of great antiquity, and excellent examples of antecedent rivers. They follow the old southerly drainage direction, showing the paradox of cutting through the great 1000-foot ridges at right angles, and ploughing their way across the anticlines.

Heights

Heights were determined by aneroid on the camel traverse, and the methods will be discussed below. The reduced level of each camp is marked on the map. The heights of ridges above camps were determined in various places. The camps being all on the level valley floors or by stream beds, these figures give the heights of the ridges above the general level of the surrounding country. The only heights obtained by levelling in the country are those along the

Circle Gulley and Finke River: looking south

Simpson Gap in the Chewings Range

Ellery Creek waterhole and Gap in the Heavitree Range

UNIV. OF MICH.

Circle Gully, James Range

By permission of "The Australasian"

railway line. The elevation of the Alice Springs railway station is 1902 feet, and of the post office (Telegraph Station), 1926 feet.

The height of Mount Gillen was determined as 1400 feet above the landing-ground, by aeroplane altimeter. The pilot gave me a rather exciting ride during this determination, almost touching the summit and diving down into the abyss of the plain several times. The Heavitree Range has a steep dip slope on the southern side which can often be climbed, but is almost vertical for several hundred feet on the north side. The height of Mount Gillen is thus approximately 3300 feet.

The spur of the Heavitree Range on the north side of Camp 2, at the Jay, is 300 feet above the valley. The ridge is here dying out. No. 3 Quartzite on the south side is 234 feet above the plain. An interesting point noted in traversing these longitudinal valleys between the quartzite ridges is that the ridges do not vary much in height, dropping away quite rapidly as a transverse stream and gap is approached, but the valley floors slope evenly and gently from the divides between the streams to the stream on each side. Thus at the divides, the enclosing ridges are comparatively low, and as the gaps are approached the quartzite walls appear to rise. The quartzite has withstood erosion well, showing practically only the effects of the transverse stream which has cut across it, while the short lateral streams have graded the valley floors but scarcely affected the hard ridges. In the Glen Helen Valley, between the Hugh and Ellery Creek, at Camp 4, the No. 3 Quartzite is only about 50 feet high, and the same thing is noticed between Ellery Creek and the Finke, also between Boggy Hole and the tributary of the Hugh, at Camp 15, where the walls of the valley are very low owing to the 500-foot gradual rise in the valley floor. An exception to this gradual rise in the valley floor is the eastern end of Horn Valley, which is scarcely cut back at all each side of Ellery Creek, as mentioned above. The Heavitree Range at Ellery Creek Water Hole is 900 feet above the creek bed. One thousand feet can be taken as about the average height of this, the main, ridge, above the flats each side of it. At Ellery Creek the fall in the ridge towards the gap is more abrupt than in most cases.

Mount Sonder was the only peak I ascended. The local opinion was that it had never been scaled, and I was naturally anxious to attain the small distinction of being the first to climb it. However later reading disclosed that Tietkens ascended the most southerly peak, with the results mentioned above. In Winnecke's account of the Horn Expedition he states, "Dr. Stirling, Mr. Belt, and Mr. Cowle essayed the ascent of Mount Sonder, but after climbing over rough ranges for many hours they were compelled to return to camp without having visited the highest point of the mountain." This party and Tietkens both approached from the south side and had first to scale the main ridge, when they would be confronted by three peaks, the centre the highest, extending in a north-easterly direction. They probably followed up the continuous rise to the first peak. I approached from the east side and first ascended to the saddle between the two northerly crests and then climbed the remaining 680 feet up the difficult ascent to the summit of the centre peak. The height by aneroid from Rockbar Gap was 2163 feet, and the height above sea-level 4482 feet. Winnecke computed the heights of all the peaks, but as he did not ascend them, he must have done it by angular measurements from his camps, the

heights of which he determined by aneroid. He does not give any details of his methods. He gives Mount Zeil (his Mount Heuglin) as the highest peak in the ranges, 4756 feet, and for the others, Haast Bluff (his Belt Range) 4649 feet, Mount Razorback (his Mount Zeil) 4040 feet, Mount Sonder 4496 feet, and Mount Giles 4210 feet. Tietkens by aneroid found Mount Razorback to be 1831 feet above his camp, and Mount Sonder (nearest peak) 4295 feet. As the camp on the Davenport was at about 2200 feet, this gives 4031 feet for Mount Razorback and Mount Sonder 4695. My determination of 4482 feet for Mount Sonder agrees remarkably with Winnecke's 4496 feet, more closely in fact than the order of accuracy of the determinations would lead one to expect. On the other hand, he gives 1643 feet for the Mission Station, against my 2013. His figure for the Telegraph Station was 2002 feet against the actual 1926 feet.

It took me three hours to climb Mount Sonder from near the base, and unfortunately it was 6 p.m. and near sunset when I reached the summit, so that the camera results were poor although visibility was still good. A wonderful

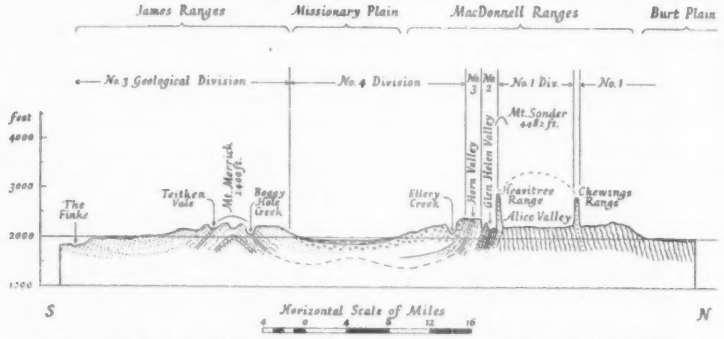


Fig. 2. S.–N. Section across Fig. 1, 3 miles east of the 133rd meridian

view is obtained, but it does not seem so unique after the experience of flying over the country. The mountains are covered with spinifex, which makes climbing most trying owing to the poisonous pricks of the long needles of this plant, *triodia irritans*. The central peak has only a small flat area on the summit, and before leaving I lighted the spinifex when darkness had come on. This bright beacon burned till 9 p.m. and was seen at the Mission Station 30 miles away, and by two other parties in the vicinity, to their great interest. I realized afterwards the local value of this proof of conquering the summit. Though perhaps not the highest peak, Mount Sonder is the most majestic in appearance, and the best known, as it can be seen from almost anywhere in the Missionary Plain, and is a prominent and spectacular landmark in the ranges. In the latter the Heavitree Range may be seen on the left, dwarfed by Mount Sonder itself. I had an exciting climb down in the dark, with many falls into the spinifex, and met my companions near the foot starting out as a search party. My spare time was occupied for the remainder of the journey in removing the tips of spinifex spikes from my arms.

The ridges passed through by Ellery Creek south of the waterhole, in No. 4 geological division, rise to about 250 feet only above the stream-level, as do the cliffs of Todd Glen in the James Range, though in the latter the heights rise to a maximum of 600 feet at Mount Merrick, which we climbed. The Waterhouse Range also rises to about 250 feet above the plains, but its general elevation is some 200 feet above that of the James Range, in the neighbourhood of the Finke.

A south–north section to true scale across the MacDonnell and James Ranges in the neighbourhood of Ellery Creek, 3 miles east of the 133rd meridian, has been drawn. This section crosses all the ridges, and may be regarded as a generalized section for the whole area. It shows the simple structure of the ranges, in addition to the main geological divisions, and the relative relief of the country.

Notes on the use of the Aneroid

Considerable care was taken in determining heights by aneroid, and as opinions on the reliability of this instrument seem to vary, it may be of interest to give an account of my methods, tests, and conclusions. The aneroid was a new one of English make, about 4 inches in diameter. On the journey north by rail it was read at fourteen stations between 1 and 7 p.m. one day, at heights varying from 1000 to 2000 feet. The stops at stations were only of a few minutes' duration, and the readings were taken at about twenty-minute intervals. For average movements of 200 feet the instrument was found to lag on an average of 16 feet on a rise or fall, but the error was up to 40 feet for movements of 400 to 600 feet. These errors are due to hysteresis in the metal.

In order to determine instrumental errors, the absolute heights of these stations were calculated by reference to the weather map of that date, and the barometer readings for stations in the vicinity, kindly supplied by Mr. Bromley of the Commonwealth Meteorological Office, Adelaide Branch, from which the height of the barometer, corrected and reduced to mean sea-level for the time and place, were obtained. To calculate the height, this reading was taken as that for the lower station, the aneroid for the upper station, and the Smithsonian Meteorological Tables Nos. 51 and 52 were employed. The temperature as read at the time of observation must be taken as the same as at the barometer from which the weather maps are made, and only the correction for temperature is worth considering. These temperatures will be about the same if the stations are near and the time the same. The 'Hints to Travellers' tables give sensibly the same results but are not so elaborate or rapid to use. The same method was used in determining the heights in the ranges, the height of the barometer at the lower station being that of the Alice Springs post office instrument, and temperatures were supplied with the readings by the Meteorological Office. To the difference in heights calculated was added 1926 feet, the reduced level of the post office by railway survey.

The calculated heights of the railway stations showed a remarkable degree of accuracy. The greatest error was 33 feet too low at the highest point, 1973 feet. Six stations were too low, with a mean of 14 feet low, and six were high, with a mean of 15 feet high. Some stations were within 1, 3, 6, and 8 feet of

the railway survey figure. This was very satisfactory, and indicated a zero index error.

The aneroid was read every morning, while travelling, at 8.30 a.m., the hour at which all the stations make their records for compiling the weather map. Alice Springs is one such station. I at first intended to calculate heights from interpolations from the weather maps, but an inspection of the latter, the originals of which were kindly lent by the Meteorological Office, showed that the pressure conditions in the centre of the Continent were extraordinarily constant during the time of the expedition, the end of May, and the whole of June. High-pressure areas of low gradient, with very little variation or daily movement, were centred between the centre and east or south-east sides of the Continent. The one-tenth inch isobars were almost east and west in the latitude of Alice Springs, from which station I was always within 80 miles to the west or south-west.

The isobars were never nearer than 200 miles apart, usually about 300 miles, sometimes as much as 1000 miles. Thus reference to the actual readings of the barometer at Alice Springs was preferable to interpolation between isobars drawn in an area of very few stations, none nearer west than Western Australia. The list of 9 a.m., 3 p.m., and 9 p.m. readings, with temperatures, was obtained from the Meteorological Office. The lowest reading for the period of five weeks was 27·883 inches, and the highest 28·288 inches, the mercury hanging around 28 most of the time. The difference in sea-level readings between Alice Springs and my positions would never have been more than 20 feet.

Readings on three mornings at the Alice Springs hotel, 2 miles from the post office, calculated in this way, gave its height as 1895 feet. The railway station near by, a little farther from the bank of the River Todd, is at 1902 feet. From this result, in addition to the tests on the railway, it appeared that results reliable to a few feet should be obtained, and that the instrumental error was zero. When the heights on the expedition were calculated however some annoying discrepancies were discovered, which could not be due to errors in reading. The determination of height on three successive mornings at Camp 2 gave 2040, 2066, and 2052 feet, which were satisfactory. At Camp 5, Ellery Creek waterhole, three successive mornings gave 2184, 2195, and 2204 feet, the camp apparently steadily rising, but not to any alarming extent. At Camp 11, a week later however, 4 miles down Ellery Creek, and thus some 50 feet lower, four successive mornings gave 2235, 2260, 2237, and 2232 feet. The mean at the waterhole is 2194, and 4 miles lower down, 2241 feet, showing a rise of 47 feet, yet the results in themselves are fairly consistent. A single reading at the Finke Gorge gave it as 50 feet higher than the single reading at Camp 6 on the Ormiston, upstream, two days before.

Finally, on return to Adelaide, instead of leaving well alone, I had the aneroid tested over a month, alongside the Meteorological Office barometer in Adelaide. It was found to have a very uniform mean error of +0·233 inch over a range between 29·2 and 30·0 inches, whereas the other tests had indicated no instrumental error. It was then taken for a single comparison to the Stirling West post office in the Mount Lofty Ranges, at an altitude of 1600 feet, and found to have an error +0·175 inch at 28·5 inches, whereupon it narrowly escaped

destruction. In spite of these observations I was obliged to adhere to my original determination of a zero index error, obtained at the outset under travelling conditions in the north country. The instrument may have been damaged on the way down.

These tests are placed on record for what they are worth. They occupied a lot of time and thought, and the results were not very encouraging to one's faith in the aneroid as an instrument of precision. My conclusion was that this particular instrument could be relied on to a few feet for determination by difference of the relative height of hills and valleys when the period of observations was measured in hours, and conditions were constant, but for determination of absolute heights in large areas over periods of weeks, errors might be up to 100 feet, even with the greatest care.

PROBLEMS OF THE EARTH'S CRUST: *A discussion in Section E (Geography) of the British Association on 28 September 1931 in the Hall of the Society*

THE following statements, prepared for the discussion, were read or communicated to the Section at the morning session. At the afternoon session several more communications were made, and there was a general discussion of which no shorthand note was taken. But we hope with the help of the speakers to reconstruct the discussion and publish it in the Journal for December.

SIR HALFORD MACKINDER (President):

Some months ago, when the Organizing Committee of the Section met to consider our programme, I ventured to suggest that the time had come when we might with advantage have a review of the present state of knowledge and speculation in regard to the major features of the lithosphere of the Earth, and Mr. Hinks kindly undertook to organize a discussion with contributions from various specialists so that we might see how far there was, as yet, a convergence of views. It is right that at the outset I should mention to you, with respect and regret, the name of Wegener, who, as you know, recently lost his life as an explorer in the arctic regions. I hope however that our debate will not centre exclusively round the hypothesis of the drifting of the continents which will always be associated with his memory; there are other great allied problems, such as the origin of the mountain ranges, and of the larger features of the coast-lines; also the rise and fall in the level of the coast-lines, and the outline of the continental shelf; all these must have connected causes. The lie of these features is important to us as geographers, and we ask for all the light on the subject which can, as yet, be given to us by the astronomers, physicists, mathematicians, and geologists. I call on Mr. Hinks to read the opening paper.

MR. ARTHUR R. HINKS:

The boundaries between Geography and the other sciences whose names begin with Geo- are not strictly kept. The frontiers are exposed to reconnaissance and raid from either side, and boundary questions, politics, and even

warfare add zest to our scientific life. But one hears complaints that contending parties do not always play the game. Having rashly undertaken to open a discussion on Problems of the Earth's Crust, which must be argued principally in this border territory, I have thought of examining the rules of the game which may govern such discussions, to see if it will help in sorting out and evaluating the arguments of very varying weight which have been put forward.

The last ten years have seen great advances in the mathematical and physical treatment of our problems. To realize it you have only to look at the difference between the first and the second editions of Dr. Harold Jeffreys's book 'The Earth.' That second edition is an impressive canon of the laws of geophysics as they are formulated by the mathematicians. Few of us are competent to criticize the mathematics, yet many feel that the present dicta of mathematicians are not the last word on the subject. What should be the attitude of geographers when confronted with a proposition against which they can produce evidence but have not the mathematical ability to refute? Let us consider a few examples drawn from the past.

I. Detection of mistakes in purely mathematical reasoning may safely be left to brother mathematicians. The greatest mathematicians have occasionally made such blunders; and Todhunter, in his 'History of the Theory of Attraction and the Figure of the Earth,' remarks of a certain treatise that it added nothing to the subject, but repeated two mistakes of Newton with a little added emphasis. Nowadays a mathematical blunder does not long survive: there are too many competent critics about.

II. But misapplication of mathematical processes is more common. We may instance Hayford's "depth of isostatic compensation," which he fixed at 120·2 km. from figures which properly interpreted meant no more than that if there were such a thing as a uniform depth of compensation it was indeterminate from those figures, but perhaps somewhere between 60 and 150 km. This remark has been made at intervals for the last twenty years, but the apostles of isostasy still repeat that "that depth was the most probable one as the limit for crustal material" ('Physics of the Earth,' ii, 108). It seems easier to get away with a misapplication than with an error.

Another misuse of the Theory of Errors was made by Wegener in his discussion of the frequency curve of heights above and depths below sea-level. He reproduces a diagram from Trabert showing a great excess of frequencies just above sea-level and at about 5000 metres below. He asserts that if a single equilibrium level existed the frequency should be controlled by the Law of Errors of Gauss and be distributed about a single maximum near mean-sphere-level, about —2450 m. The two maxima show that there are two undisturbed original levels, the continents and the ocean floors, and consequently two different layers of the body of the Earth. Mr. Lake has remarked that the law of errors can have nothing to do with the matter, since it would assume that consecutive deviations were equally likely to be positive and negative. A simpler objection seems to be that the upper maximum is merely dependent upon sea-level having been much the same throughout geological time, and would have appeared in any case, whether the continents and the floor of the ocean were of different material or not.

III. Still more fruitful of evil is accurate reasoning from faulty or insufficient

premises. A classical example is Kelvin's determination of the age of the Earth, from gravitational considerations, before anything was known of radioactivity. Conditions of any geophysical problem are so complex that striet mathematical investigation is usually impossible. The best that the mathematician can do is to simplify his foundations of hypothesis by clarifying assumptions, and the test of their adequacy is whether they do or do not lead to contradictions either of theory or of fact.

The former again we may safely leave to the mathematician. The recent battle between Eddington, Jeans, and Milne on the internal constitution of the stars refutes the paradoxer's suspicion that scientific men are in league to bolster up one another's errors.

IV. To confront the mathematician with new facts is the primary duty of geographer and geologist: facts in support of his conclusions, or, better still, facts in contradiction. Long series of accurate wireless longitudes may one day demonstrate that continental drift which is at present declared inexplicable by theory and calculation. Long-continued determination of trigonometrical heights may in time refute the isostatic paradox that denudation increases the height of a mountain. Laboratory research may find alternatives to the tachylite and dunite whose physical properties seem at present best to fit the analysis of earthquake waves. One principal advantage of having a mathematical theory is that it enables us to arrange our facts in an orderly way to confront it. If they confirm, well and good. If they do not, it is for the mathematician to explain why the conflict is apparent and not real, or alternatively to reconsider and improve his theory.

V. But the mathematician is entitled to insist that the geographers and geologists and climatologists do not simply ignore him and his results. Specious theories of continental drift and wandering of the poles have been built on slight foundations, largely of convenience. Mathematical inquiry and calculation, so far as it has been carried at present, is against the possibility of either being effective. Yet in a recent ambitious study of ice-age climates Dr. Simpson has this astonishing sentence: "As it is not my intention in this paper to consider all possible alternative explanations, I may say at once that I adopt Wegener's hypothesis of the drift of the continents and the movement of the poles as being the explanation of the main glaciation"—just as if these ideas were generally accepted and nothing had ever been seriously alleged against them. That is scarcely playing the game. It is nothing against a mathematical argument that a majority of geologists or climatologists prefer to ignore it, as they too often do, as if mathematics were a question of taste or opinion. As another example of this attitude take Professor Joly's theory that the whole subcrust liquefies periodically and that the crust is then towed round by tidal friction. Dr. Jeffreys holds that such periodic liquefaction is contrary to all theory and all experiment, and that even if it could happen, the calculable effect of tidal friction is inadequate to move the crust, though it might stop the rotation of the whole Earth. It seems to me clear that until Professor Joly can show where the physics and mathematics are wrong or inapplicable he must be non-suited; for he cannot produce any evidence that what he supposes actually happened. He can say only that if it could, 'twould very conveniently explain things.

May I interpolate here that Dr. Poole will bring forward arguments in favour of Joly's periodic liquefaction, with which I am hardly competent to deal; but I do not gather that he has anything to say against Jeffreys's contention that the tidal friction demanded by Joly would be enough to stop the rotation of the Earth very quickly.

VI. Mr. Frank Bursley Taylor goes much farther on this adventurous path ('Theory of Continental Drift: a Symposium,' p. 175). "If we were permitted to entertain what seems to the writer to be a simple, rational explanation of the origin of our great satellite, the moon—if we were permitted to believe that the moon was acquired by the earth suddenly by direct capture out of space, and that this event occurred in the Cretaceous period—almost all of the difficulties of explanation would disappear. . . . It is true [Mr. Taylor admits] that most astronomers now reject the theory of the origin of satellites by direct capture; only a few have favoured it. But those who oppose it would do well to take note of the rapid rate at which facts of observation favourable to that theory are accumulating." This dark threat to the simple astronomer seems to mean that if one assumes this capture of the moon, and that the Earth was before the capture rotating more slowly, and that the orbit of the newly captured moon was "surely much more eccentric" than its present orbit and the tides at perigee perhaps a thousand times greater than they are now, and that the effect of tidal friction is to speed up the rotation of the Earth, not the reverse as is usually believed, then Mr. Taylor "sees at once the explanation of almost everything associated with the Tertiary-to-present diastrophism." And believing that the sudden capture of the moon is the explanation of all these things, he finds in these things a demonstration of the sudden capture of the moon, and starting again from that now well-established fact we may go over the argument afresh and gain complete conviction.

Now this is not a burlesque but a quite serious indictment of the kind of exercise that passes for argument nowadays on our frontiers. There are geologists who do not scruple to play fast and loose with the principles of every other science than their own. They turn the frontier into a no-scientific-man's land. We shall make no real advance until we can re-establish in these border-territories a respect for scientific law and morals.

We set out to discover the Rules of the Game. I suggest that they are effectually comprehended in this simple proposition: No man may adopt a principle contrary to the best opinion in another man's subject. The important word in this rule is of course *adopt*. Every one is free to doubt another man's principles and should be encouraged to collect evidence against them, but he must give time for defence, and must not anticipate the verdict. Take for example the hypothesis known as the wandering of the pole. Mathematicians are firm that the rotation axis cannot move within the body of the Earth more than a very small amount; they are prepared to admit that the skin of the Earth might move as a whole over the body and thus displace the continents with respect to the poles, but that there is no known force sufficient. Geologists and meteorologists have got into the habit of thinking that they can move the poles about at pleasure, and some do not even take the trouble to specify whether it is the rotation axis or the skin which they are treating so light-heartedly. They must be more precise, and more respectful to the best opinion in

astronomy, that refuses to give way on the first, and has no business with the second.

Let us try now to suggest some lines on which discussion of Crust problems may be invited.

Movement of the Poles

Mathematicians cannot admit any considerable movement of the axis in the body of the Earth; they have no *a priori* objection to a movement of the complete skin, except the utter inadequacy of the forces at present suggested. The geologist must be given many years in which to obtain and marshal his evidence, and must distinguish most carefully between evidence for movement of the skin as a whole with respect to the poles of rotation, and differential movement in the skin, otherwise continental drift. When he can bring a clear and indisputable body of evidence as to facts it will be the duty of the mathematician to explain them if he can; but meanwhile the geologist on a partial view of the facts must, I think, defer to the mathematician, who will not require urging to keep his eyes open for forces which have escaped him up to the present.

Continental Drift

The mathematical possibilities of continental, that is to say, of differential, drift in the crust seem to be much less. There is a very slight tendency for a floating continent to drift equatorwards in the magma, and a very slight westward tendency due to tidal friction. When they are put into figures, as by Dr. Jeffreys, they seem altogether inadequate to move a continent through the magma, even if a continent were floating as cleanly and squarely in a nice smooth magma as the text-book figures suggest. We are, in fact, invited to think of a continental mass under almost no horizontal forces ploughing its way steadily through an ocean floor, which resists its advance enough to squeeze up folded mountains against nothing at all, as Rastall says, yet allows it to trail away festoons of islands behind. Rastall pleaded for suspension of mathematical judgment on continental drift until geology and other observational sciences have shown whether such drift did or did not take place. Nothing could be more reasonable, on condition that until that time geologists and others shall suspend talking as if the case had already gone in the affirmative.

Mountain building

The principal question at issue is whether the distortion of the crust by folding and crumpling is or is not greater than can be explained by contraction on cooling or by slowing up rotation. There has been a sort of competition among geologists to demand contraction measured in hundreds or even thousands of kilometres. "The fix'd Stars," said Fontenelle to his Countess, "cannot be less distant from the Earth than fifty millions of leagues; nay, if you anger an Astronomer he will set 'em farther." The mathematician has only to indicate that he sees some hope of providing more crustal compression than is required to produce the Alps, and the geologist invites him to Central Asia and demands seven or eight times as much. We may suspect that this is to some extent sensation-mongering, a desire to make our flesh creep; which judgment is supported by observing that those who find contraction insufficient straight-

way refuse to admit that it has any effect at all in mountain building. "Geology has not yet completely freed itself from the idea of a shrinkage of the earth," said Wegener in the beginning of his second chapter, and a little later spoke of the contraction theory's complete bankruptcy. Such language in the face of Jeffreys's calculations is inadmissible. If, which is not yet certain, the thermal contraction is insufficient, it must be allowed to have played a large part, and we can still draw something from the contraction of the crust arising from a decrease in the flattening with decreasing rotation, though by far the greater part of that probably came too early in geological time to be of much use to the builder of Tertiary mountains.

Isostasy

It is generally agreed that visible masses do not exert their full calculable effect either upon the direction of the vertical or upon the intensity of gravity, but are to some considerable extent compensated by deficiencies of density below, more completely in some parts of the world than in others. The theory of isostasy, according to Bowie, declares that "if the earth's crust were cut into prisms of the same cross-section by imaginary vertical planes, the prisms would have the same mass if the isostatic conditions were perfect. This means that the pressure exerted by these prisms on the subcrustal material at the depth of 60 miles below sea-level would be uniform throughout" (Bowie, 'Physics of the Earth,' ii, chap. vii). The essence of the theory is that there is some depth at which compensation is complete, and that this depth is the same all over the Earth. For convenience of calculation it is assumed that the deficiency of density under visible masses or the excess under ocean floors is distributed uniformly down to the depth specified: 120·2 km. according to Hayford, but somewhat reduced to 96 km. by Bowie by taking into account the gravity determinations as well as the deviations of the vertical in the United States.

Bowie says (*loc. cit.*) that "the father of isostasy is generally recognized to be George B. Airy, at one time Astronomer Royal, Greenwich Observatory, England," but proceeds to quote from his paper in the *Phil. Trans.*, vol. 145, 1855, thus: "I conceive that there can be no other support [for mountains and tablelands] than that arising from the downward projection of a portion of the earth's light crust into the deeper lava . . ."; and later from Pratt in his last paper (*Proc. R.S.*, 1871, vol. 19, p. 224), ". . . that the amount of matter in any vertical column drawn from the surface to a level surface below the crust is now, and ever has been, approximately the same in every part of the earth." The doctrine of what Bowie calls isostasy is Pratt's. Airy's was the doctrine of compensation by "roots of the mountains." It seems to me to be important to get this distinction clear, firstly because all the work of Hayford and Bowie is on Pratt's hypothesis of equal mass in columns of equal section above some level surface (not, be it noted, Pratt's other hypothesis to explain it, of vertical expansion in the columns, which Jeffreys examines and rejects on pp. 192–3 of his second edition); and secondly, because in his chapter *The Theory of Isostasy*, p. 193 is headed "Failure of Pratt's Hypothesis," meaning the second, not the first. At the bottom of the page we read: "In what follows the mechanics of Airy's theory, which accounts automatically for the compensation of all surface irregularities, however produced, will be adopted. It provides

that every surface projection or depression large enough to produce permanent deformation in the weak layer will be compensated. The strong layer will be usually called the lithosphere, and the underlying one the asthenosphere, following Barrell. The distinction between them is not very definite, as the actual transition in properties is not very continuous, but is nevertheless worth making. The thickness of the lithosphere is a matter for special investigation; it is not obviously identical with any of the layers revealed by seismology or even with any set of them."

Jeffreys then makes the good point that the difference between the uniform columnar compensation of Pratt and the root compensation of Airy is not so fundamental in theory, but depends on the normal distribution of density with depth; and since seismology proves that the change of density is sudden at particular levels, compensation must actually be concentrated near the bases of those levels, which Heiskanen has shown is consistent with the facts of observation. Perhaps the word "near" is rather misleading, since the roots must be extensive, and often it would seem deeper than the undisturbed layers. Anyhow, the whole trend of modern opinion is towards Airy's root-compensation and against Pratt's columnar.

This being so, I would urge that the word "isostasy" should be dropped. The celebrated paper in which Major C. E. Dutton employed it was published in 1892, and has been reprinted at least three times in recent years, but without safeguarding the meaning of the word. Major Dutton wrote: "For this condition of equilibrium of figure, to which gravitation tends to reduce a planetary body, irrespective of whether it be homogeneous or not, I propose the name *isostasy*. I would have preferred the word 'isobary,' but it is preoccupied.... If the earth be not homogeneous—if some portions near the surface be lighter than others—then the isostatic figure is no longer a sphere or spheroid of revolution, but a deformed figure bulged where the matter is light and depressed where it is heavy. The question which I propose is: How nearly does the earth's figure approach to isostasy?" After referring to George Darwin's investigations into the question how large a mountain could support itself, Dutton turns to geology, and concludes that "it may be laid down as a general rule that where great bodies of sediment have been deposited over extensive areas their deposition has been accompanied by a subsidence of the whole mass," and that "wherever broad mountain platforms occur and have been subjected to great erosion the loss of altitude by degradation is made good by a rise of the platform.... It seems little doubtful that these subsidences of accumulation deposits and these progressive upward movements of eroded mountain platforms are, in the main, results of gravitation restoring the isostasy which has been disturbed by denudation on the one hand and by sedimentation on the other." Whatever we may think of his choice of a word, it seems clear that in the earlier part of his paper what Dutton meant by isostasy was the conservation of the external form of the Earth in spite of the processes of erosion and deposition. Nowhere does he speak of anything remotely resembling either uniform columnar or root compensation.

Towards the end of his paper it is less clear what Dutton means by isostasy. He is discussing the cause of general elevations and subsidences, and says: "Now it is sufficiently obvious that the theory of isostasy offers no explanation

of these permanent changes of level. On the contrary, the very idea of isostasy means the conservation of profiles against lowering by denudation on the land and by deposition on the sea-bottom, provided no other cause intervenes to change those levels. . . . Whatever may have been the cause of these great regional uplifts it in no manner affects the law of isostasy. . . . Hence I infer that the cause which elevates the land involves an expansion of the underlying magmas, and the cause which depresses it is a shrinkage of the magmas. The nature of the process is, at present, a complete mystery."

It is generally said that Dutton coined the word "isostasy." He did it, I think, with the aid of Liddell and Scott's lexicon. He would have preferred *isobary*, but found it already engaged. A classical scholar informs me that Liddell and Scott give the adjective *ἰσοβαρής* as used by Aristotle in the sense "of equal weight." Dutton fell back on "isostasy," evidently from the adjective *ἰσοστάσιος*, which was used by Plutarch in the sense "in equipoise with," and by Hippocrates and Lucian in the sense "equivalent to"; he had some kind of equilibrium in mind, but what kind is far from clear. Unfortunately, he adopted a word which suggested, to Hayford at any rate, columns of equal mass standing upon a level surface, and that, with the last words quoted, which are the conclusion of the paper, led to the very artificial conception which is what Hayford and Bowie mean when they use the word "isostasy." Jeffreys uses it in a much wider sense, but not at all that which Dutton seems to have had in mind when he first proposed the word. Considering further that "isostasy" has been adopted now by some who use it as a slogan or a catchword, and will tell you that uplift of mountains is impossible because it is contrary to the principle of isostasy, you may be willing to agree that the word was of doubtful meaning in its first use, that it has acquired other meanings of doubtful value, and that it is better not to use it. The "principle of isostasy" does not, with all respect to Dr. Bowie, involve the idea of some one depth at which compensation is complete. The principle of compensation of mountain masses is accepted, but root compensation is much more probable than uniform column compensation. If this terminology is not in itself acceptable, we must get to work again with Liddell and Scott.

A last word on compensation: we have been encouraged to assume that the process is always going on, and that anomalies of gravity should be regarded as temporary. Dr. Vening Meinesz has recently discovered a remarkable belt of negative anomalies in the Netherlands East Indies which shows that there is in the sea surface an actual depression some 30 or 40 metres deep at its deepest, which makes a kind of boundary ditch between Asia and Australasia: it coincides almost perfectly with the modern equivalent of Wallace's line, and the implication is that it is a very old feature, which invites discussion.

DR. G. C. SIMPSON:

I am deeply interested in the problems referred to by Mr. Hinks, but I will confine my remarks to the two which fall into my own sphere as a meteorologist, or rather as a climatologist: the movement of the Poles and Continental Drift.

Mr. Hinks says that "Geologists and meteorologists have got into the habit of thinking that they can move the poles about at pleasure, and some do not even take the trouble to specify whether it is the rotation axis or the skin which

they are treating so light-heartedly." I cannot of course speak for all geologists and all meteorologists, but I can definitely state that the accusation does not apply to some of us, and least of all to Wegener. I wonder whether Mr. Hinks is aware that Wegener graduated at the Berlin University with an astronomical dissertation, and that for several years he was actively engaged in the Urania Astronomical Observatory at Berlin. Wegener was a mathematician and astronomer before he became a meteorologist, and therefore was quite familiar with the mechanics of a spinning body. When Wegener speaks about the movement of the pole he means relatively to the material of the Earth itself. The Earth's axis has always been inclined at approximately $66\frac{1}{2}°$ to the plane of the ecliptic, and neither Wegener nor any one else has suggested that that inclination has changed appreciably. So long as the Earth was considered to be a rigid body it was impossible to accept any movement of the mass of the Earth relatively to its axis of rotation—or, to put it shortly, any movement of the pole. The bulge of the equator would in such circumstances be a rigid fixed feature determining the axis of inertia and so the axis of rotation. In such circumstances there could be no movement of the pole relative to the rigid material of which the bulge consists.

But Wegener, arguing from the lessons taught by isostasy, showed that the Earth is not rigid; in fact, for slow changes it is almost a perfect liquid. A rotating liquid globe is very different from a rotating rigid globe. In a liquid globe the bulge is there, but the material of which it is composed at one moment can be moved into any position relating to the axis of rotation. Internal and superficial currents can exist in a rotating liquid globe and transport surface features and internal masses into any position relatively to the polar axis, which then becomes only an abstraction and not a material region.

I admit that it is unfortunate that the expression "movement of the poles" has come into such general use, but I think that Mr. Hinks is making a mountain out of a mole heap when he suggests that geologists and meteorologists do not know what they are talking about. Geologists and meteorologists are not primarily concerned with the dynamics of the rotating Earth, but with the relative positions of the poles and the surface features, and these are most easily described by the expression "movement of the poles."

I now pass on to the question of Continental Drift. If what I have already said is accepted, then continental drift is as least understandable. The drift of the continents may be due either to a movement of the surface skin alone or to deep-seated movement of the material of the Earth. We have no means of deciding which, and in the present state of our knowledge it is immaterial. The chief question is: are there any reliable data which give evidence of a movement of the continents relative to the pole? It is here that I can speak as a meteorologist. There are certain laws of climatology which must always be obeyed. I went into these very thoroughly in a discussion held at the Royal Society in 1930 (*Proc. R.S.B.*, 1930, vol. 106, p. 299). I will only refer to two of them now:

(*a*) Owing to the shape of the Earth there must always have been climatic zones concentric with the polar axis.

(*b*) The temperature of the climatic zones must always have been decreased from the equator to the poles.

Now when geologists tell me that they find every evidence of a polar climate on a continent now at the equator, while another continent now near the poles had at the same time a warmer and probably subtropical climate, then I say that those two continents must have changed their positions relatively to the poles. It does not worry me that the mathematicians say that such a movement is impossible. My answer to the mathematician is that the simplest explanation of the observations is a movement of the continents relatively to the poles—or, more simply, a movement of the poles—and until the mathematician or any one else can supply a better explanation I shall accept the simple one. If Mr. Hinks is so certain that there has been no movement of the continents, then he must do one of two things: either he must show that the geologists are wrong when they say that during the Carboniferous or Permian Periods there were great ice-sheets in parts of the present equatorial regions simultaneously with luxuriant vegetation in Greenland; or he must show how it is possible to have the temperature increasing from the equator to the poles. In the meantime I propose to adopt Wegener's hypothesis even if that involves my "not playing the game."

DR. J. H. J. POOLE:

The problem of the thermal history of the Earth is not at all so simple as it formerly appeared. Before the radio-active elements were discovered the cooling of the Earth was considered to be similar to the cooling of an ordinary laboratory specimen, except, of course, on a very much larger scale. The main difficulty then was to explain how the Earth took such a long time to cool. Since the discovery of these elements however and their estimation in available terrestrial materials, the boot is entirely on the other foot, for now we are forced to make rather uncertain assumptions to explain how the Earth has ever cooled at all.

We can calculate the total heat lost by the Earth, and hence the maximum amount of radio-active elements it can contain if it is in a steady state of cooling. On the cooling Earth theory we must believe that measured surface radio-activities do not at all represent the true state of affairs, but that on the average the Earth is very greatly poorer in these elements. Furthermore, it has been shown that to account for the present apparent solidity of the Earth even this small quantity of these elements must be confined to a depth not exceeding 50 kilometres. I might observe, in passing, that I agree with Professor Holmes in considering this latter deduction one of the most difficult to accept in the Cooling Earth Theory.

It is accordingly of interest to examine what would occur supposing the Earth were more radio-active than postulated. The Earth is usually considered to have been liquid at the surface at one time. Cooling, at this stage, would be very rapid, and I think there is no reason to believe that the presence of the radio-active elements would invalidate Lord Kelvin's argument that solidification in the outer rocky shell of the Earth would take place from the bottom upwards. I have not time here to enter into a discussion as to the effect of pressure on the melting-point gradient, but I think solidification would really start at the level where the density of the solid was equal to that of the liquid. This preliminary solidification would leave us with a crust nearly at its melting-point everywhere, but completely solid.

Suppose however that at certain depths the temperature exceeds the melting-point of the materials; the consequence will be that below a certain critical depth melting will occur in our originally solid crust. We are left with a solid crust overlying its own liquid. Dr. Jeffreys holds that this is a stable arrangement, and must persist for an unspecified period, until the radio-active elements have been concentrated in the upper solid crust to such an extent that complete solidification could occur. The subsequent cooling can then be treated by the laws of heat conduction in a solid, although I may observe that the initial conditions seem rather difficult to arrive at.

Now Dr. Jeffreys's original objection to Professor Joly's hypothesis was undoubtedly based on the difficulty of avoiding a steady state. He preferred to express this by saying that the heat conduction equation has no periodic solutions. This is undoubtedly true, as long as the periodicity is not a forced one, *i.e.* one introduced by a periodicity in the boundary conditions, as in Angström's well-known method of measuring heat conductivities. I hope however to have shown that the arrangement is not stable, granted that the crustal materials behave like a material possessing a definite latent heat, melting-point, and other physical properties.

A liquid layer trapped under a solid layer always tends to move slowly upwards. I have developed these ideas in a paper in the *Proceedings* of the Royal Dublin Society, vol. 19, no. 32. Enough has been said, I hope, to prove that we can avoid a steady state without invoking any external agencies, such as crustal shift produced by magmatic tides or other rather unpredictable phenomena.

Turning to the objections to the views here expressed, my own chief objection is to the assumption of definite melting-points, etc. The crust certainly does not fulfil this condition. This does not mean that the stability of the liquid layer is established thereby; it only involves a suspension of judgment till the actual properties of the material and their effect on the question are better known. I should like to emphasize most strongly however that there is nothing either in the primary laws of heat or of experimental experience which renders a cyclical theory impossible. It all turns ultimately on the at present unknown physical properties of the materials involved.

Dr. Jeffreys has more recently urged another objection to all cyclical theories, based on the evidence of the present strength of the crust. Owing to the observed imperfection of isostasy the crust must be capable of supporting loads normally of the order of 200 metres, and running up locally to some kilometres. He argues that the change of temperature generally assumed in these theories would not allow us to imagine that the crust could develop such strength. Here again we are faced with the question of the actual properties of the material. Personally, I must say I am rather impressed by this argument, but I would point out that indefiniteness in the melting-point, if it allows cyclical changes at all, would probably also have the effect of increasing the range of temperature in a revolution. There is also the possible effect of real supercooling effects in the magma, *i.e.* cooling below its normal melting-point before freezing; but no one has yet been brave enough to introduce this further complication. We might expect this also to have the effect of increasing the temperature range.

If I may discuss the cooling Earth theory for a moment I think all physicists must agree that given the conditions assumed as regards the distribution of the radio-active elements, it is absolutely unassailable from their point of view. Geologists may argue that quantitatively it is not perfect as regards the amount and time intervals of mountain-building periods. It also does not permit continental wanderings. The chief objection to it is however the difficulty of explaining how such a distribution of the radio-elements could have arisen. The original solidification must have occurred very rapidly, and hence presumably no time for segregation of these elements would then have been available. The consequent concentration must have been all brought about by intrusions from below, and it seems inconceivable that by such a process such a perfect separation could be attained in any conceivable time. Professor Holmes, who was largely concerned with the early development of this theory, has however put the case against it very strongly in the *Transactions of the Geological Society of Glasgow*, vol. xviii, pt. 3, 1928–29. The conclusion of the whole matter seems to be that no theory is perfect; but all possess their own peculiar advantages and disadvantages.

PROFESSOR J. W. GREGORY:

I regret that the work of Section C prevents my attendance to express the pleasure with which I have read the opening statement as to the limitations of mathematical dicta on some problems of physical geography. It seems hopeless however to expect any result from one of Mr. Hinks's warnings, as it appears impossible to shake the general belief that the 120-kilometre depth of compensation associated with isostasy is an established fact.

Mr. Hinks appears to imply that all geologists believe in drifting continents, and in shifting poles, and in the moon having been vomited out of the Pacific in primeval or perhaps as late as Cretaceous times. I think that the majority of geologists do not accept any one of these three theories. As regards the wandering of the poles, I have repeatedly urged that the geological evidence is in favour of the North Pole having occupied approximately its present position in all the geological periods of which we have adequate evidence; for the North Polar faunas have been always stunted and poor in comparison with the contemporary faunas of lower latitudes. The conclusion that the fossil floras prove former tropical conditions in the Arctic has been invalidated by Professor Seward and other fossil botanists.

As regards continental drift on the Wegener scale, the evidence summarized in two recent Presidential Addresses to the Geological Society on the Geological Histories of the Atlantic and Pacific Oceans shows that no such drift has taken place, and that the valid evidence advanced in its support can be explained by vertical movements of the crust. So far from all geologists accepting this drift the latest pronouncement, by the late Dr. von Jhering, published last month in the *Quart. Journ. Geol. Soc.*, lxxxvii, p. 376, states that the Wegener theory is rejected "by all German geologists with whom I have been in contact." Wegener has received wide support from his fellow meteorologists, but the balance of geological opinion seems to me emphatically opposed to it.

The geologists who have supported the theory have been influenced largely by hypotheses of mountain structure which make extravagant demands on

overthrusting. The proved overthrusts are explicable in other ways. The size of some assumed overthrust nappes in Asia and the transfer of masses of North Africa to the middle of Switzerland should be proved before they influence general conceptions of earth structure. The amount of contraction of the Earth required by the geological evidence and its distribution through geological time are not opposed to mathematical dicta. That the Earth's crust has undergone contraction throughout geological times seems to be one of the best established of geological facts, though the process may have been intermittent.

I doubt whether it is possible, or desirable, to discard the term "isostasy." The confusion between the Airy and Pratt conceptions is probably due in part to their not being absolutely opposed. Would not the subcrustal flow in consequence of the development of Airy's condition lead to movements to secure the columnar equilibrium of Pratt's? Dutton, when he proposed the term "isostasy," depended on the geological evidence that the coincidence of subsidence with sedimentation and of uplift with denudation has been so frequent that it is reasonable to conclude that they are cause and effect. It is true that Dutton did not discuss the Pratt and Airy explanations; but he probably had both processes in mind as the possible cause of isostasy. He was concerned with its geological effects and not with the mathematical explanation of its ultimate cause. Dr. Bowie, if he has not always kept the two conceptions apart, has clearly explained and illustrated both of them. Probably both are in operation but in different areas. The trouble with isostasy is the length to which it has been carried, and those who have advocated a more moderate application of the principle are told that only the extreme form of the doctrine is worthy of consideration.

Dr. Meinesz's work makes clear that the depth of the sea-floor is not determined simply by the specific gravity of the mass below. Isostatic equilibrium is shown by the geological evidence not to be a world-wide condition, and its distribution is probably dependent on conditions due to the crust sagging to secure support from the contracting interior.

PROFESSOR ARTHUR HOLMES:

The problems open to discussion under this very broad title are so varied and intricate that we may be grateful for having our attention focused on certain critical aspects of the questions at issue. At present we see no more than a few doubtfully solved patches in a jigsaw puzzle of infinite complexity. I shall confine myself to three of these patches and offer a suggestion which, if valid, may go far towards uniting them into a more continuous picture.

Isostasy.—It is unfortunately true that the word "isostasy" has been seriously overworked and thoughtlessly used as a slogan. But the term has become so deeply rooted that its extermination might now prove impracticable. I therefore continue to speak of *isostasy*, but discriminate, as Jeffreys has done, between isostatic equilibrium and isostatic readjustment. The former is a condition that tends to be restored by the latter when some geological process has disturbed a pre-existing equilibrium. The most common misconception with regard to isostatic readjustment is to consider it as an active cause of disturb-

ance, whereas it is, on the contrary, a process that is brought into play only when isostatic equilibrium has been independently upset.

Where mountains are still in a state of active growth, as in the Netherlands East Indies, the crust is thrown out of equilibrium faster than isostasy can restore it, and it is in such regions that the greatest anomalies of gravity are found.

If the actual density below a station is higher than the assumed density, then the computed value of gravity g_c is too low and the anomaly $g_o - g_c$ becomes positive. Such an anomaly is therefore not necessarily an indication of a departure from isostatic equilibrium. The widespread positive anomalies found by Dr. Venning Meinesz over parts of the Atlantic and Pacific floors may be at least partly accounted for by the probability that the density of the sub-oceanic rock is considerably higher than that adopted in the standard method of computation.

Systematic positive anomalies have also been recently found by Dr. Meinesz over the Gulf of Mexico. These may reasonably be accounted for by the occurrence of heavy material beneath the deeper parts of the Gulf. The anomalies over the submarine part of the Mississippi delta are of particular interest because of the discussion as to the extent to which delta deposits may be an uncompensated load on the crust. In 1914 Barrell suggested that deltas were actual loads sustained by the strength of the crust. If this were indeed the case, the excess of mass would give rise to a positive anomaly. Bowie found soon afterwards that eight stations on the Mississippi delta gave an average anomaly of −0·007 cm./sec^2, from which he concluded that the delta was nearly in isostatic equilibrium. Longwell has recently (1930) argued against this conclusion. Assuming that the thickness of the sediments is 15,000 feet and that their average density is 0·4 less than the value adopted in computing g_c, he finds that g_c is too high by 0·060, that is, $g_o - g_c$ should be −0·060 if isostatic equilibrium were complete. He then concludes: "Since this negative anomaly does not exist, the measured gravity is abnormally large, and therefore the delta is overloaded." The new submarine measurements of gravity over the Gulf throw a fresh light on this problem. They reveal positive anomalies averaging about 0·040 but ranging in the deeper and less sedimented parts up to 0·062, 0·070, and 0·080. Against these figures the anomalies over the submarine part of the delta average 0·006, while those over the delta-land itself average −0·007. Relative to the unsedimented sea-floor, the anomalies required by Longwell to demonstrate isostatic equilibrium of the delta are thus found to exist. The negative anomalies of the Indo–Gangetic plain may be regarded in the same way as a symptom of the undoubted deficiency of density that obtains there as a result of depression and the accumulation of thick layers of light sediment.

Forces other than gravity and the Earth's rotation may be disturbing a region so vigorously that isostatic readjustment perforce lags behind. The residual anomaly would then be an expression of the struggle between the active force and the process of readjustment stimulated by it. After the force had ceased to act, it would express the still remaining tendency towards restoration of equilibrium. When the ice melted away from Fenno-Scandia the unloaded area must have been left with a considerable negative anomaly.

Isostatic adjustment has ever since been at work smoothing this out by uplifting the region, and even now, after some 18,000 years, the process is slowly continuing where equilibrium has still not quite been reached.

A more difficult case to interpret is that of the really astonishing belt of negative anomalies recently discovered by Dr. Meinesz in the East Indian Archipelago. The most remarkable features of the strip are: its parallelism to the trend lines of Tertiary to Recent folding and volcanic activity; its coincidence with the belt of maximum liability to earthquakes (including earthquakes of abnormally deep foci); and its independence of surface inequalities. Now if, as Dr. Meinesz thinks probable, the negative anomalies are essentially a consequence of downward folding of light material, then they should be most marked in the neighbourhood of islands with roots of sial, and less conspicuous over the deep ocean floor where presumably there is little sial material available for making light downfolds. Actually the facts are the reverse; the negative anomalies over the deep ocean range from −0·070 to −0·200, whereas over or near islands they are only −0·020 to −0·080.

The effect of lateral compression on the vertical column of sial beneath the islands would be to thicken it, and time would be required for the downward displacement of the underlying material. Thus the region would show a positive anomaly until readjustment succeeded in catching up. In an oceanic strip free from a capping of sial, compression and shear would transform the deeper parts of the column into a still denser metamorphic facies such as eclogite; the strip would be overloaded from the start; it would tend to sink, giving a deep in the ocean floor, and the gravity anomaly would be positive to begin with. The actual departure from isostatic equilibrium in deeps giving negative anomalies is therefore even greater than the latter might suggest.

The island parts of the East Indies negative strip are less negative (*i.e.* more positive) than the oceanic parts. We have still to explain how this difference has been shifted from the positive field to the negative field in which they actually occur. In addition to compression something appears to be happening beneath the strip which results in its being held down well below the position it would occupy under pure compression. The only kind of process competent to provide compression and at the same time to exert a downward drag against gravity would seem to involve the operation of two opposing subcrustal currents which approach the strip and turn down beneath it. The origin of the Indo–Gangetic depression is probably to be referred to a similar process.

The Contraction Hypothesis of Mountain Building.—In his most recent treatment of the Earth's contraction, Jeffreys ('The Earth,' 2nd ed., 1929, p. 282) concludes: "The uncertainties in all the determinations however are such that we can only say that the compression of the crust is of the order of 200 km., it may easily be half or twice this." The reduction in the area of the Earth's surface corresponding to a shortening of 200 km. is 5 million sq. km., but this reduction has to be spread over the whole history of the Earth since the crust solidified. On any cooling hypothesis the rate of reduction would be greatest at the beginning of the cooling process, and would become steadily less as the present was approached. If we take the age of the Earth at 1600 million years (m.y.), and consider the Mesozoic and Kainozoic foldings (conveniently

referred to as "Alpine") to represent the contraction accomplished during the last 200 m.y. (rather an over-estimate), then the reduction in area during this last 200 m.y. must have been less than 12·5 per cent. of the total and may have been as little as 6·5 per cent. The reduction available for the Alpine disturbances therefore lies between 1·25 and 0·16 m. sq. km. (allowing fully for Jeffreys's "half or twice"), with 0·5 m. sq. km. as a reasonable estimate. What is the actual reduction represented by the "Alpine" crumplings? Unfortunately no satisfactory estimate is possible. An estimate made by Jeffreys some years ago was 1·7 m. sq. km., but this must now be considerably increased. Certain ranges that were not included must be taken into account (there are, for example, very extensive overthrusts in Sumatra), and moreover the compression involved in the Alps and Rockies as well as in many older ranges is now known to be considerably greater than was formerly admitted. Shortening of the order 100–300 km. is not unusual. The total length of the two peripheral rings of "Alpine" ranges that encircle Laurasia and the continental relics of Gondwanaland is about 70,000 km. If the average shortening is only 50 km., then the reduction of area becomes 3·5 m. sq. km. This estimate has of course little value except as an indication of the order, but it seems clear nevertheless that the calculated compression is definitely less than the amount to be explained. It may be only a little less (and the difference might then be bridged by changes in rotation), but just as probably it may be twenty times too low. A more precise statement would not be justified in view of the present limitations of data.

There is a serious discrepancy between the intervals of mountain building to be expected on the contraction hypothesis and the measured intervals. The former should theoretically be shortest at the beginning of the Earth's history, becoming longer as the present is approached. As measured by the ages of associated granitic intrusions the intervals from Middle Pre-Cambrian times are 320, 225, 180, and 165 million years, in direct contradiction to the requirements of the hypothesis.

One of the best established generalizations of geology is that folded ranges have arisen on the sites of more or less long-lived geosynclines in which thick accumulations of sediments were trapped. The contraction hypothesis can give no account of the origin of these subsiding troughs. It is now generally realized that the weight of sediments cannot itself account for more than a small proportion of the subsidence that has indubitably preceded mountain building. Compression could conceivably have brought about the additional subsidence required, but had it done so it would then become necessary to assume that compression had been in constant operation throughout geological time. No intervals for the accumulation of the stresses that are called upon for mountain building would then be possible. Some geosynclines can be accounted for by the operation of tension rather than compression. The case of the Urals, clearly described by von Bubnoff, is of special interest. Abyssal sediments suddenly appear in the Lower Devonian, accompanied by basic volcanic rocks and followed by intrusions of gabbro and peridotite. Such evidence of rapid subsidence and subcrustal fusion seems fatal to the assumption that the geosyncline was a consequence of compression. The opening of the geosyncline was contemporaneous with the crumpling and overthrusting

of the Caledonian belt on the western side of the Russian shelf and Baltic shield. The contraction hypothesis seems quite incompetent to provide a mechanism which would coordinate the strongly contrasted behaviour of the Caledonian and Uralian tracts. When the latter did come under compression, at the end of the Devonian period, the sediments were folded in the usual way and invaded by intrusions of granite.

There remains to be considered the question whether the Earth has appreciably contracted at all since early Pre-Cambrian times. No one doubts that during geological time many parts of the crust have been repeatedly heated up, and that the upper levels have gained igneous material at the expense of the lower. Since cooling took place during the intervals between successive igneous invasions, it follows that the crust has suffered a great deal of intermittent contraction. But such shrinkage is bound up with a crustal circulation of material that implies for its achievement a deep-seated source of heat.

Finally, the evidence of geochemistry is strongly opposed to the idea that the substratum can have cooled to any appreciable extent since it was enclosed by the crystalline rocks of the crust. Jeffreys states quite clearly that convection would proceed in the interior until the upward concentration of the radioactive elements had become almost complete. Is it reasonable to suppose that this upward concentration was achieved in the 10,000 years that Jeffreys (p. 79) allows for it? On the contrary, it is difficult to see how so clean a separation could ever be brought about. Even if the substratum had as little radioactivity as iron meteorites it would still have too much to have reached the stage where convection would stop. The radioactive elements in a layer of granitic rocks 11 km. thick and an underlying layer of basaltic material 22 km. thick would suffice to make good all the heat lost through the continental crust by conduction. These layers exist, the only doubt being that they may be thicker. The contraction hypothesis thus leaves no room for any appreciable radioactivity in the materials below. We seem driven to adopt the alternative view that the substratum cannot yet have cooled to a crystalline or durovitreous solid. It must be an extremely rigid and viscous glass in which, in virtue of its excess heat and great thickness, convection is still slowly proceeding. On this view the Earth is still far from having reached the stage of its thermal history which is visualized by the contraction hypothesis. Until the interior is effectually freed from the radioactive elements, either by some unknown process of upward concentration or by the slow but inevitable wearing out of the unstable atoms themselves, contraction by cooling cannot begin its role as the dominant control of tectonic geology.

Mr. Hinks considers that it is inadmissible to speak, as Wegener did, of "the contraction theory's complete bankruptcy." I submit that the above assemblage of objections to the contraction hypothesis all converge in supporting Wegener's refusal to accept it. Unless these objections can be satisfactorily met, geology will henceforth be better served by rejecting a hypothesis which can provide mountains of a sort only at the expense of its inability to provide anything else.

Continental Drift.—If we accept the conclusion reached above that convection is still necessary to carry off the heat generated in the substratum (and perhaps in the core), there must be some method of discharging the excess heat through the crust. I agree that the "mathematical possibilities" of drift

are hopelessly feeble so long as the continental masses are regarded as the source of the minute gravitational forces to which mathematical explorations have hitherto been restricted. But if the continental masses (and ocean floors) are relatively passive in themselves and the source of activity is looked for in substratum currents, then a new field for inquiry is opened up and the "mathematical possibilities" of continental drift may turn out to be completely adequate.

From the physical side the position seems to be this: On the contraction hypothesis continental drift is manifestly impossible; on the convection hypothesis continental drift is essential in order to provide a means of escape for the heat carried up to the crust. From the geological side the contraction hypothesis is already discredited, while continental drift has much weighty evidence in its favour. There is of course a very deeply rooted prejudice against continental drift; and I am personally not entirely free from it. Moreover Wegener's book is rather calculated to provoke hostile reactions. It is easy to prove Wegener wrong over and over again, but proving Wegener to be wrong is by no means equivalent to disposing of continental drift. To my mind the evidence of the distribution of climates during the Upper Carboniferous constitutes a conclusive proof that both continental and crustal drift have operated on a very extensive scale. The occurrence of tillites of the same or very nearly the same geological age in South America, South and Central Africa, India, and Australia presents us with a hopeless riddle unless we assume that the glaciated lands were then grouped together near the South Pole. The grouping need not—indeed could not—have been as close as Wegener's familiar maps would have us believe, but this is a minor detail that does not affect the principle involved. If South Africa lay near the South Pole, then parts of North America, Europe, and China must have lain near the equator of the time. That they did so is suggested by the distribution of the flourishing coal-forests of the Upper Carboniferous, and perhaps more conclusively by the restriction of fossil laterites of that age to the neighbourhood of the coal belt (Harrasowitz, 1926). No vertical movements of the crust could possibly account for such spectacular climatic changes as have indubitably occurred.

Evidences of Substratum Currents.—Professor S. Chapman has recently directed attention to the possibility that the maintenance and secular variations of the Earth's magnetic field may be a consequence of a deep-seated internal circulation of material. Dr. Meinesz has pointed out another possible indication of flowage in the substratum: "The very curious time changes, *i.e.* sudden changes of the rate of rotation of the Earth, which have been found in recent years." For an account of these changes reference should be made to a paper by de Sitter. Referring to the shortening of the day that occurred in 1918 de Sitter shows that it is hopeless to look for local displacements of mass as an explanation, and, as regards the greater part of the change, he concludes, "the origin of the change must be in the deeper layers, and it must be of a world-wide, and not of a local, character" (*Nature*, 1928, vol. 121, pp. 99-106).

Considerable attention has been given recently to the study of earthquakes arising from abnormally deep foci. The distribution of epicentres up to 1927 is shown in a map by Turner. The epicentres so far recognized occur near the shores of the Pacific; along the strips of negative anomalies found by Dr.

Meinesz in the East and West Indies; and in mid-Atlantic and under the Himalayas. If these deep-seated disturbances are not in some way a result of currents operating far down in the zone of flowage, it is difficult to conceive a mechanism that could be responsible for them.

Jeffreys has pointed out that many old peneplaned mountain ranges are still represented by tracts of folded sediments, despite the fact that if they had been worn down to this extreme degree by denudation alone, both the sediments and much of the underlying granitic layer should have been removed (1929, p. 295). He suggests that these tracts have in part been lowered by "outflow of matter from the intermediate layer, with compensating inflow in the lower layer." Such an effect would inevitably be brought about by the passage of a sub-crustal current, for the latter would tend to "erode" the mountain roots, carrying away the corroded material in the direction of movement, just as ice-sheets have ground down the summits and spread out the debris in the lowlands beyond.

Other evidence suggestive of substratum currents may be drawn from gravity anomalies like those of the East Indies negative belt; from the echelon structure of the island festoons of Asia; from the rapid uplifts of the outer zones of many actively growing island-arcs; and from the migrating folds of certain Fiji coral reefs deduced by Professor W. M. Davis.

Much of this is purely speculative. But as yet little more can be expected. Discussion and speculation are justified if they do no more than stimulate a search for the more elusive pieces of the jigsaw puzzle we are doing our best to put together. If the suspected currents in the substratum are destined to form part of the completed picture, we must look carefully for possible evidences of their existence, and it is in the hope that others may cooperate in the search that this preliminary survey of a series of possibilities has been presented.

DR. HAROLD JEFFREYS:

I wish to begin by mentioning a few things that it would be of the first importance to geophysics to find out. We need a boring under the ocean. We have inferred from a number of lines of evidence that the granitic layer, which forms about the uppermost 10 km. of the continental crust, is absent from the ocean floor, though we have no direct evidence. But we do not know definitely what replaces it; the ocean floor might be dunite, basalt, andesite, or even syenite. Further, though it is generally believed that temperature gradients below the oceans are less than below the continents, we do not know how great the difference is, and a knowledge of it would be of much help towards understanding the Earth's thermal history.

We also need measurements of the thermal conductivities of the rocks from the mines and borings where the existing measurements of temperature gradients have been made. The importance of this is that the rate of outflow of heat is the product of the conductivity and the temperature gradient. But unfortunately the two have been determined together in only one place, South Africa, and this is certainly abnormal because the temperature gradient has only two-thirds of its usual value. At present the conductivity of the uppermost layers, as used in theories of the Earth's thermal state, contains an element of surmise, which could be removed.

To come to the remarks of my predecessors in the discussion, I must emphasize the need for careful interpretation of the data concerning isostasy. The principle of isostasy is not in any circumstances an exact statement of fact. In the places where it fits the facts best the assumption of isostasy reduces the largest gravity residuals to about a fifth of what they would be without any compensation at all, leaving the smaller ones very much as they were. To that extent isostasy is a first approximation to the truth. But the residuals are still, on an average, about six times the probable error of a single observation, and therefore imply real departures of isostasy from exact truth. In some places, notably most of India and some places in the East Indies recently investigated by Dr. Vening Meinesz, it is not even a first approximation.

The ordinary departures of isostasy from the truth correspond to irregularities of distribution of mass that require a strength of the order of that of brick to support them; they afford no justification for speaking of the subcrustal material as behaving like a liquid. But even if isostasy was perfect, it has nothing to do with the theory of continental drift. The displacement of continents is not a mere matter of deforming the comparatively weak lower layers; it requires distortion of the outer crust, which is under moderate temperature and pressure, and always has been, and must have its full strength as determined in laboratory conditions. That it actually has such strength is shown by the fact that it holds the Himalayas up and the Pacific Deeps down. It is entirely unjustifiable to speak as if moderate forces were enough to produce horizontal displacements of the continents, and Dr. Simpson's appeal to isostasy evades the essential difficulty.

With regard to Wegener's neglect of the evidence for the thermal contraction theory, I think it ought to be mentioned that my original work on it was published in 1916, just after Holmes's first theory of the Earth's thermal history, on which my work was based, and it is very probable that Wegener did not know of it until after the war.

I disagree with Professor Holmes's statement that in the formation of a mountain range "shortening (of the crust) of the order of 200–300 km. is not unusual." This refers to the folding measurable in the surface rocks, and I think I have shown that the shortening of the crust is a very different thing, only about 60 km. The visible folding is a secondary effect, and can be explained by gravitational readjustment during uplift.

I cannot understand Holmes's objection to the idea of strong upward concentration of radioactive matter. He himself inferred from geological evidence that in the Finland granites the radioactive constituents moved upwards when the granite was fused. If the Earth was once fluid there could be no solidification so long as the radioactivity was uniformly distributed; but so long as it remained fluid the radioactive matter would rise until solidification became possible. I cannot see why Holmes will not admit the generality of his own conclusions.

On the other hand Holmes's difficulty about the distribution of mountain formation in time has always seemed to me serious. According to the existing form of the thermal contraction theory the intervals of time between consecutive epochs of mountain formation should have increased greatly with time, whereas Holmes gives evidence, which seems to me adequate, that the actual

intervals have been nearly constant. I think however that this difficulty can now be removed. The melting-point of rocks increases with pressure, so that just after solidification the temperature would increase inwards. This gradient gives rise to an outflow of heat at all depths, which is practically independent of the time. The result is a general cooling of the order of 50° since solidification, which is the same all through the Earth. Previous estimates gave an average cooling of the order of 400°, but only through the outermost 500 km. or so. Thus a new source of contraction is available, about as potent as those already considered, but giving a distribution in time agreeing with that found by Holmes.

I do not think I need to point out the difficulties I feel with regard to Dr. Poole's theory, because he has expressed himself with such reasonableness and candour that I can think of none that he has not already mentioned.

I have examined Professor Holmes's theory of subcrustal currents to some extent, and have not found any test that appears decisive for or against. So far as I can see there is nothing inherently impossible in it, but the association of conditions that would be required to make it work would be rather in the nature of a fluke. He assumes that radioactivity is uniformly distributed in the rocky shell, from about 40 km. to 3000 km. down, and that the state of the material is neither a true liquid nor an ordinary solid, but what I have called a liquevitreous solid, possessing rigidity, but a finite viscosity and no permanent strength. Whether this state is possible at high pressures in the actual material is not known; I think the evidence is against it. But granting as a working hypothesis that it may be so, and that the supply of heat is greater than could be conducted away at the adiabatic gradient, the state of equilibrium would be unstable, and vertical currents would be generated, rising in some places and descending in others. Matter on reaching the top would travel horizontally to a descending current, and on the way would produce a viscous drag on the bottom of the crust. Holmes appeals to this drag to overcome the strength of the crust and produce displacements of the continents. The currents would be slow, but the viscosity would be high, and the drag might be great.

For the theory to succeed would require the currents to be in the same direction over regions of continental dimensions; that is, the instability developed must correspond to the lowest mode of disturbance and no other. If the supply of heat was greater than could be carried off by the currents in the lowest mode, we should get irregular motions of small extent, resembling those that occur in the boiling of a kettle, and these would be no use for producing widespread geological effects. So Holmes's theory requires that the rate of supply of heat should fall within two limits, which in a deep region like the Earth's rocky portion would probably be very close together; if it was too low there would be no convection currents at all, while if it was too high the currents would be of the wrong kind. I think therefore that while the theory merits further examination, its validity would be a remarkable accident. The positions of the currents would be very easily disturbed, so I should say it was unlikely they could be in the same places for whole geological periods.

DR. J. DE GRAAFF HUNTER:

I am much in sympathy with what Mr. Hinks has said and have for some years felt that the game was not being played, at least as regards the alleged "principle of isostasy." The signification of the word "isostasy" is certainly hazy. Dutton's words indicate a condition of equilibrium under gravitational forces. Dutton stated as a general rule that denudation or sedimentation were followed by movements tending to restore isostasy or equilibrium. This seems a matter of mechanics, pure and simple, if one assumes that the Earth's crust has a limiting strength, which is overcome when sedimentation or denudation occurs on a sufficiently large scale.

Hayford did a considerable service to geodesy in putting this mechanical idea into a form in which it could be applied to geodetic observations. To do this he incorporated certain assumptions, notably that compensation of all surface features is complete at a certain depth; and that compensation is uniformly distributed in vertical columns down to that depth. Now this bears much similarity to Pratt's compensation, but goes farther. While Pratt began by considering that the Himalayan Mountains were compensated in this way, and later suggested that the Indian Ocean might be similarly compensated, he does not appear to have contemplated the more general compensation of all topographic features. Hayford however, quite legitimately, introduced the hypothesis that all topography was compensated as a basis of computations which he proceeded to make with the U.S.C. and G.S. data. He found that a great part of the anomalies then disappeared. So far so good. His hypothesis was not contradicted, though it would be wrong to say that no other conceivable hypothesis would have fared as well. Encouraged, and perhaps misled, by this measure of success other workers in other fields made corresponding reductions of their observational data. The results were not always so favourable to the hypothesis. Some workers have essayed to reconcile their results by tampering with the hypothesis of uniform columnar distribution of density, and if successful have rather inconsistently claimed this as support for Hayford's hypothesis.

During the last decade or more the statement has often been made that the "principle of isostasy" has been proved; which I take to mean a belief in the broad truth of Hayford's hypothesis as a fact everywhere over the Earth. Dr. Bowie has gone so far as to suggest that the geoidal form may be computed on this basis from a knowledge of the topography, leaving further observations for gravity apparently redundant. Very recently (*Journal of the Washington Academy of Science*, vol. 21, p. 105, March 1931) he finds the strongest point of the Darwin-Fisher idea of the throwing off of the Moon in the fact that "it does no violence to isostasy." Now let us consider the evidence for this principle to justify such use of it. In the first place the main regions in which the geodetic data of plumb-line deflections and pendulum anomalies have been acquired are in Europe, the United States, and India; but none of these regions has been by any means completely explored gravitationally. Until the last decade no reliable results were possible at sea; but latterly Dr. Vening Meinesz, having overcome technical difficulties, has made a large number of determinations. All told perhaps some 3·5 per cent. of the total surface of the Earth has been explored gravitationally.

Now were the results all, with no considerable exception, uniformly favourable to Hayford's hypothesis of isostasy, an optimistic person might be content to accept the evidence of one-thirtieth of the Earth's surface as indicating the truth of the hypothesis all over the Earth. A lesser optimist might go no farther than accepting the hypothesis merely as a hypothesis which had a good deal of truth in it. But the evidence is by no means all one way.

Evidence from the whole of the Indian continent, excluding the Himalayan region but embracing a million square miles, is strongly contradictory of the actuality of the hypothesis. For example, there is an area of 100,000 square miles between the Himalaya and the Ganges, where the departure from the hypothesis is represented by an average equivalent of over 2000 feet thickness of surface rock. As the topography to be compensated here only rises to heights of a few hundred feet, and this 2000 feet has actually been swelled by assuming compensation, one has a flat contradiction for compensation according to Hayford here. In the Himalaya, so far as data allow a conclusion to be drawn, there is evidence of an anomaly averaging about 800 feet over portions averaging 8000 feet in height; so that one may well favour the idea of mountain compensation approximating to Hayford's idea. But Continental India as a whole denies Hayford as regards non-Himalayan regions. Again, Dr. Vening Meinesz has found an area of 500,000 square miles where a very large systematic negative anomaly persists, equivalent to a defect of nearly 3000 feet of rock.

So far then we have about as much adverse evidence as there is favourable evidence for the hypothesis; and the whole evidence deals with about one-thirtieth of the Earth. To me it seems madness to consider that the hypothesis of Hayford should be regarded as a principle. This is no reason however for denying its value as a convenient basis for computation and discussions of anomalies. For various reasons I strongly advocate this use. But it should be recognized that the ideal state of Hayford compensation is merely used as a standard from which anomalies may be reckoned.

In view of the implications which have latterly become attached to the word "isostasy" by unjustified reiterations of its "proof," I agree that it would be best to drop the word altogether. "Ideal compensation" would generally convey as much as is justifiable.

THE BRITISH ARCTIC AIR ROUTE EXPEDITION

TO take up the summary of its proceedings from the last instalment in the *Journal* for September: The six members returning on the *Gertrud Rask* reached England at the end of August, and the number remaining in the field was five. We should note first that the traverse from Angmagsalik *via* the ice-cap station to Holstenborg, which had been allotted to Rymill and Chapman, was actually undertaken by Rymill and Hampton, who left the base, it is believed, about August 18. There are reasons to think that on local advice they intended to make for Sukkertoppen, on the coast about 45 miles south of the S. Stromfjord mouth, instead of going to Holstenborg, and they might have reached the coast about the end of September. But the nearest transmitting radio station is 100 miles farther south, at Godthaab, and the news of their arrival might well be delayed.

After helping Rymill and Hampton to ferry their material across the fjord, the coasting party (Watkins, Courtauld, and Lemon) left the base on August 15 in an outboard motor-boat, towing another boat, which served as a store-ship. On September 17 reports in Copenhagen said that the radio station at Angmagsalik had received a message from Lemon that in bad weather the motor-boat had broken down at Akorniamiut; and for some time it was doubtful if the party were sledging across to Julianehaab or would be compelled to winter at Umivik. No further message was received until October 10, when a telegram from Julianehaab announced that they had repaired the motor and successfully completed the voyage on October 9, after a good deal of delay by bad weather. The transmitting set had been put out of action by sea water, which explained the silence.

The position then was that Watkins, Courtauld, and Lemon would have been able to catch the steamer of the Cryolite Company at Ivigtut twenty-four hours from Julianehaab, about October 25, had news been received from Rymill and Hampton. These two were to leave their sledges at an agreed place at the head of the fjord, and make their way to the coast by kayak (if these had survived the sledge journey) or across country on foot. The fact that their arrival had not been reported to Watkins by October 17 gave no reason for anxiety: but he and Courtauld decided to go north on that day, with the intention of visiting the head of the fjord if the party had not by that time arrived at Holstenborg or Sukkertoppen. However on October 23 news was received in London that Rymill and Hampton had reached Holstenborg by kayak, all well, and on the 27th Watkins telegraphed from the ship *Hans Egede* that they would all be home by the middle of November. On his arrival the date of his lecture will be arranged and announced to Fellows by postcard.

THE STUDY OF NATURAL CATASTROPHES

PUBBLICAZIONI DELLA COMMISSIONE ITALIANA PER LO Studio delle Grandi Calamità. *Roma: R. Accademia Nazionale dei Lincei* 1931. 11×8 *inches*. Vol. I. L'Unione Internazionale di Soccorso. By GIOVANNI CIRAOLO. 400 *pages*. Vol. II. Memorie Scientifiche e Tecniche. By ROBERTO ALMAGIÀ, ALFONSO CAVASINO, ARCANGELO ILVENTO, RAOUL MONTANDON, EMILIO ODDONE, and DOMENICO ROMANO. xvi+326 *pages; maps*

TO enlighten the reader on the origins and scope of the above Commission it is necessary to go back to the year 1921, when Senator Giovanni Ciraolo, of Italy, President of the Italian Red Cross from 1919 to 1925, at the Tenth International Red Cross Conference at Geneva submitted a scheme for international cooperation and mutual assistance with the object of preventing where possible, or at any rate mitigating, the consequences of natural catastrophes. He stated that natural calamities knew no economic or political frontiers, and that in order to meet them it was necessary to make careful and thorough preparations based on experience and scientific study of the causes of and phenomena connected with such natural calamities, including particularly the geographical factors. As a result of this proposal the International Relief Union was established by the Geneva Convention of 12 July 1927, for the preparation and coordination of assistance in the event of catastrophes due to natural causes.

The two volumes under review contain the results of the work of a special Commission appointed in Italy for the above purpose by the Presiding Council of the R. Accademia Nazionale dei Lincei. The names of the members of the Commission, all distinguished in various branches of science, are evidence of the importance which the Italian Government attach to the study of origins and means of prevention of those great natural calamities which so often take place in that country. The Commission decided to restrict its studies to those natural catastrophes which are historically recorded as most frequent in Italy, the Italian Islands, and surrounding countries of the Mediterranean Basin.

The first volume of the publications under review contains an account of the origins and development, the programme and structure of the International Relief Union, from the Ciraolo plan in 1921 to the Geneva Convention of 1927. The second volume contains information gathered together, first by Professor Almagià on the distribution of landslides in Italy, and by Professor Ilvento on the distribution of serious epidemics; second by Dr. Alfonso Cavasino on the distribution of catastrophic earthquakes in countries belonging to the Mediterranean Basin; a report by Dr. Romano on the organization of services for warning of and assistance in earthquakes as well as on earthquake-proof building in Italy; and finally an accurate list of publications on the subject of natural calamities compiled by M. Raoul Montandon, President of the Geographical Society of Geneva. A third volume, not yet received, is stated to contain two studies by Dr. Leone Kawan on famines and on migrations respectively, while further reports are stated to be in course of preparation on volcanoes, earthquakes, floods, droughts, exceptionally severe winters, etc.

The first volume is of little interest from the geographical point of view. In his preface to the second volume, M. Montandon states that national commissions for the study of calamities have been set up in Austria, Belgium, France, Italy, Switzerland, and Hungary, but not yet in Germany, United States of America, Roumania, Greece, Great Britain, Spain, or Portugal. The aim of these national commissions is to make inquiries regarding the calamities which more particularly afflict their own territories or those of their dominions or colonies. Research work of a more general character should, M. Montandon suggests, be

carried out by international committees of experts in the various subjects to be studied. The results of these researches should then be submitted to the International Relief Union (Unione Internazionale di Soccorso) for unification and coordination. With this object the Italian Commission expressed the hope that an international meeting of experts should be held as soon as possible at Geneva, having as its programme: (*a*) to define the scope of the contributions which various scientific bodies can make to the Union by studying the origins, development, dangers, and possible preventions of great natural calamities; (*b*) to help in drawing up a list of calamities of such magnitude as to be included within the action of the Union; (*c*) to take necessary measures to unify the methods of study and distribute the work among the various commissions of different countries; (*d*) to initiate collaboration between them, drawing up a programme of common research into certain of the most serious calamities.

M. Montandon goes on to call attention to the work already accomplished, *e.g.* a report read at Madrid by Señor Beltran Rozpide, of the Geographical Society of Madrid, on the subject of the geography of calamities. He notices also the recent offer of Professor Alan Ogilvie of Edinburgh to take up the question of the geography of calamities. M. Montandon has himself prepared a work entitled 'La distribution geographique des calamités et leur succession dans le temps,' as well as a map of the world showing the geographical distribution of calamities.

Further, the French Commission on 7 November 1929 passed resolutions: (*a*) for the immediate despatch of a scientific mission to study the biology of locusts in N. Africa; (*b*) to study the causes of forest fires; (*c*) to apply forthwith scientific measures for the protection of the inhabitants of French Colonies against natural calamities, cyclones, volcanic eruptions, etc., which measures had formed the object of study on the part of the Administration; and as soon as any results of such measures had been obtained, to bring them to the knowledge of the International Relief Union.

As a result of the information so far received by the Union and extending over four periods of twelve months each (too short a time to reach any final conclusions) it would appear that, for these four periods at least, on an average about 285 calamities of the kinds under review occurred in 70 countries for each period of twelve months—showing that such calamities vary between 250 and 300 per annum; and that the countries in the first rank were every time for the four periods in question the United States, Italy, Japan, Germany, Spain, and France.

These conclusions rest naturally on very fragile premises so far, but M. Montandon points out that if such statistics were obtainable for a large number of years it should be possible to fix the geographical distribution of such natural misfortunes; the regions of the globe that are most subject to them; the repetition in periods or cycles of certain calamities; and the possible existence of constant features in great natural phenomena. M. Montandon concludes with a short review of the different calamities, scourges, catastrophes, etc., which may come within the scope of the activities of the International Relief Union.

In the first paper contributed to the second of the two volumes Professor Roberto Almagià deals with the geographical distribution of landslides in Italy. He divides landslides into five categories, though all are produced by the action of water. The worst landslides occur where sandy clays are found, and appear most frequently in Sicily, Calabria, the Emilian Apennines, Chietino, Molise, and Basilicata. Other types take place generally on steep and rocky mountainsides, and are therefore more common in the Dolomites. From the map attached to this paper it appears that while the west coast for some distance inland from

north of the Arno to the south of the Bay of Naples, the valley of the Po, and great parts of the eastern coast-line of Italy are immune, the worst landslides occur in the Abruzzi, Apulia, Basilicata, and Calabria.

The next paper is contributed by Professor Emilio Oddone. It deals with the frequency of earthquakes of disastrous proportions in the Mediterranean Basin, with a chronological catalogue of such calamities in this area since 1501. Explanatory notes are contributed by Dr. Alfonso Cavasino, together with an extremely interesting chart of the area showing the regions most affected, the worst spots being the Ionian Islands, where Zante has had nineteen visitations during the period above mentioned, Santa Maura ten, and Corfu five; while Smyrna and Constantinople have suffered from ten, Messina, Malta, Ischia, Scutari in Albania, and Candia five or six each. Italy, Greece, and Albania are evidently the centres of this disturbed area; there is no province of Italy which appears to be immune. It is curious and interesting to note that no serious earthquakes seem to have taken place during the period mentioned either in Corsica or Sardinia, although these islands are so near the area principally affected.

Professor Arcangelo Ilvento contributes an extremely interesting paper on epidemic diseases in the Mediterranean Basin. The diseases on which the Italian Commission on calamities decided to report are cholera, plague, typhus, scarlet fever, malaria, and tuberculosis, these being considered as presenting a general index of the sanitary conditions of the populations of their respective countries. Professor Ilvento gives a detailed history of epidemics of plague with a statistical table showing geographical distribution and numbers of cases of quinquennial periods from 1900 to 1925. Attached to this are charts for the countries of the Mediterranean Basin, including also Portugal, South Russia, Mesopotamia, Persia, and Arabia, showing numbers of deaths from plague between 1900 and 1909; 1910–19, and 1920–25. Professor Ilvento further contributes a report, statistics, and a chart on the distribution of cholera, typhus, small-pox, etc., all of which should be of great service in facilitating any international action to reduce or terminate these scourges, but are hardly of a nature to require detailed review here.

The two final papers in this volume are contributed by Dr. Domenico Romano, Director-General of Special Services in the Ministry of Public Works. In the first, after pointing out that Italy has suffered almost more than any other country from natural calamities, especially earthquakes, he goes on to show that, perhaps for this reason, Italy is doing pioneer work in organizing measures, if not for the complete prevention of such natural calamities, at least for reducing as far as possible the misfortunes consequent upon them. He points out that measures taken suddenly under pressure can rarely be so effective as those prepared by a permanent organization. The former nearly always result in waste, overlapping, and inefficiency. It is therefore of great importance that there should be some permanent standing authority to deal with such natural calamities in countries where they are known to occur, and, under that authority, a disciplined organization which can act with knowledge, efficiency, and speed. The Italians have therefore set up an organization for the service of immediate relief in case of calamities of various kinds. Dr. Romano next describes the various centres for immediate relief established throughout Italy and their methods of working, all of which would doubtless well repay the study of those parts of the British Empire which are liable to natural calamities of the kind to which Italy is subject. One subject with which he deals at length is that of the prevention of and warning against floods, which are of frequent occurrence and especially disastrous if not provided against in different parts of Italy, especially in the great Plains of Lombardy, Venice, and Emilia.

In the second of his papers Dr. Romano describes what is being done in Italy to promote scientifically the construction of earthquake-proof buildings. Ever since the eighteenth century this matter has been the subject of study by various governments, especially that of Naples, with results satisfactory up to a point, and to-day the art of constructing earthquake-proof buildings has been considerably advanced. Dr. Romano gives a detailed report of the present position which must also be of real use to architects in those countries where earthquakes occur. The volume concludes with a catalogue of publications on natural calamities general and particular.

It is impossible to give even a cursory glance at these volumes without being struck by the evident advantages in store for humanity generally, if the study of the origins of all such calamities in different countries, their cure, their prevention, and the most suitable measures to attenuate their consequences, were to become the subject of serious international cooperation and coordination. The plan of Senator Ciraolo, who first gave expression to this idea, is undoubtedly both useful and practical. Although we in Great Britain are fortunately singularly free from such scourges there are many parts of the Empire which are afflicted by them (for instance cyclones in the West Indies and Mauritius, earthquakes in New Zealand, floods, droughts, and epidemics in India); and here our experiences in the past might be of the greatest help to other countries and that of other countries of great assistance to us in the future. From this point of view the present volumes are both valuable and welcome.

HOWARD OF PENRITH

CORAL REEFS AND ATOLLS

CORAL REEFS AND ATOLLS. By J. STANLEY GARDINER. *London: Macmillan & Co.* 1931. 9×6 *inches;* xiv+182 *pages; illustrations and maps.* 10s 6d

THIS book is much overdue; it was planned before the war, and the author's pressing duties might have deferred it still longer but for the invitation to give the Lowell lectures at Boston last year. The great increases in knowledge bearing on coral-reef problems since the days of Darwin and Dana remained hidden in various journals, and have never yet been put together to compose a single view. We had Davis, whose immensely interesting book deals mainly with only one of the geological aspects, and Yonge, who added to our knowledge of the biology of corals; but these are only two features of a picture complex in its composition and crowded with detail. All has been compressed into these 180 pages, nothing of relevance omitted, yet the main composition never obscured by the multitude of detail. As a consequence what is of value in the old material blends with the new, and only a reader familiar with the original literature can distinguish the two. Professor Gardiner's own researches, which necessarily occupy a considerable portion of any book on this subject, are equally subordinated to the preservation of unity, and his deliberate judgment on his own work is as valuable as that on the work of others.

The descriptive part of the work is vivid and deeply interesting, but to many readers the account of the present state of our knowledge of reef origins will appeal more strongly. We are constantly given indications of the gaps in our knowledge, and of the direction of future research, with no final judgments or emphasis on special theories, where they are still premature. The present writer confesses to the same prejudice against Darwin's theory as he has against certain

ladies; it is *too* perfectly beautiful. He therefore enjoys the more the present volume, with its careful and forceful presentation of the facts, judicial summings up, and intentional lack of finality.

In the picture of the reefs the reader is led from the visible, and to some extent familiar—the islands and their inhabitants, men, animals, and plants—to the less familiar—the surface reefs and their multitude of organisms, the bricks and the mortar, the protective paints, the rusts and the destroyers, the interactions of which result in the reef, growing, stable, or in decay. Physical and chemical factors have to be considered, and much remains to be learned of them. All this however is but the moss along the top of a castle wall, with this difference, that, so far as all our evidence goes, the growth of this moss does account for much of the bulk of the castle itself. Atolls are the greatest and most interesting of all forms of reef, and their foundations, though often volcanic, are more often unknown. The picture of island formations in Lecture II is, from the human point of view, drawn from the more fortunate atolls; few of the Pacific atolls bear breadfruit or bananas, coconuts and fish being their only products; even the dogs live mainly on coconuts and catch fish for themselves. In the formation of the islets the changes of ocean level, recrystallization of limestone, and the deposition of guano by the countless thousands of seabirds which periodically make a "fair" for breeding have all had their effects. The "natural history of corals" gives every relevant fact in 22 pages; the other builders, plants, hydrocorallines, and alcyonaria take 36; other organisms, a whole host of forms, from lovely coral fish to stinking enteropneusts, 17; the most important are those, a very various host, which by boring into or rasping the surface of the builders render them a prey to the waves, either whole, or so rotten that they are easily broken into sand. This is swallowed by holothurians, worms, etc., and reduced to a fine mud, which is either dissolved or swept out of the lagoon, to be added to the vast deposits of the deeper water of coral seas. Every one who has visited a coral reef has been impressed by the huge numbers of these creatures, and the figures given of the effects of their activities are most striking, but probably the action of boring algae is more important than all the others.

One of the strongest impressions on the reader is the magnitude of the atoll problem. Too often the enormous sizes of many atolls, which again may be but fractions of the great ocean banks on which they lie, may be overlooked. The atoll problem is not a curiosity of natural history and local geology, but one of earth physics. Indeed, the masses concerned rival any of those mountain ranges to which attention has been so much more freely given.

The subject of lagoon formation is still under debate, but the facts and reasoning given show that solution (using the term to include every agency) is a sufficient explanation. If lagoons are generally filling up it appears strange to the reviewer that so few show unequivocal signs of the fact. There has been time enough, yet the only cases he remembers are Cocos Keeling and Napuka Atolls, and one section of the barrier reef of Tahiti. The rest of the great host is as described, the outward growth of the reef compensated for by the enlargement of the lagoon, so that the reef remains much the same breadth in spite of its growth.

There are two points of disagreement upon which it is desirable to comment. No reefs formed by algal growth were found by the present writer in the Cape Verde Islands, and indeed the immense vigour of nullipore growth there, without any reef resulting, indicates that a shoal or reef being completely covered by nullipores is no proof that it owes its origin, or much of its bulk, to them. Secondly, it is impossible to share the author's admiration for the work of Alexander Agassiz. Where his coral-reef work has been checked it has been found to be superficial and inaccurate, with facts distorted to fit ready-made theories. There is no need

to enlarge upon so painful a subject, but for the fact that emerges: that the Tuamotu Atolls of the Central Pacific and most of the Society Group remain entirely unexplored, and should be the subject of a full-sized expedition, the members of which should pay no attention to what has been already written, but approach their islands as though they were their first discoverers.

Misprints and inaccuracies are few and have no effect on the book as a whole. Fenna occurs for Fenua once; and "Leilei" is not a Polynesian but Fijian word, "Iti" meaning "little" in the former tongue. *Heliopora* does not occur on all reefs, not having been seen in the Red Sea, Zanzibar, or Tahiti. *Tubipora* occurs at low water-level in large masses on outer reefs of the Red Sea. The major variations in water-level in the Red Sea are due to the monsoons in the Indian Ocean; local winds, blowing towards the middle area of low pressure, produce smaller and temporary effects. We should have been much happier at Dengmab if the rainfall had reached 1 inch annually!

The illustrations, very carefully chosen, are both beautiful and new. Even the necessary figures of anemones and coral polyps are novel, and rendered with exceptional clearness by the artist, Miss Gardiner, while Colonel Sewell's corals at lowest tide, surf on the reef edge, soft corals of a shore reef, etc., combine quite pre-eminently artistic excellence with clarity of illustration. Of Professor Gardiner's photographs two have appeared in journals, but the majority are printed for the first time. The charts and diagrams number thirty-three, and are each and all drawn so that, while nothing is omitted, the essentials are not obscured by detail. The originals are quite inaccessible to the general reader. In short, every geographer, biologist, and oceanographer will find this book of the greatest value. The specialist may wish, as does the present writer, that it had been expanded to five times its length, with a whole long chapter devoted to such problems as "What happens to corals when they die?" but while the general reader will enjoy brevity and clarity, the specialist will find food for thought in every sentence. After all, the long discussions on the existence of granitic rocks in the mid-Pacific Islands are quite sufficiently summed up in "All those [islands] are volcanic and mostly basaltic, not an ounce of granite having been discovered as yet." Snail specialists, microlepidopterists, and Easter Island theorists may bitterly regret it, but the most imposing and expensive volume could say no more. Nevertheless we hope for a later and much larger volume from Professor Gardiner; possibly by then the gaps in our present knowledge will have been partially closed—or will they have widened, as they have done so greatly since Darwin's time? We have great hopes of the new methods of seismic and echo sounding, but much biological and geological exploration, of the good old-fashioned kind, is still wanted, and echo soundings must be checked repeatedly by borings and bottom samples.

This book will stimulate interest in these problems by showing not only their breadth and complexity but their importance as world structures, and we hope that this interest will result in work being resumed, both by expeditions and individuals, for their solution.

CYRIL CROSSLAND

REVIEWS

EUROPE

BY MOUNTAIN, MOOR AND LOCH TO THE DREAM ISLES OF THE West. By THOMAS NICOL. *Stirling: Eneas Mackay* 1931. 8×5 *inches;* 202 *pages; illustrations.* 7*s* 6*d*

It is really a little difficult to believe that the demand for this type of book can be equal to the supply. Repeated descriptions of the Trossachs and Killiecrankie do not make them any more attractive. But let us at least be thankful that Skye, the overwritten isle, is only just touched in these discursive pages. By far the most interesting and valuable chapters are the four describing the life of man and bird in St. Kilda, with which the author is evidently well acquainted. It seems a pity that he did not concentrate his pen and camera exclusively on this "lonely western outpost," which was recently brought into public notice by the evacuation of August 1930. Some good illustrations of the St. Kildan cliffs and their teeming population would have been preferable to indifferent photographs of Glencoe and other well-known places. The fancy picture on the paper wrapper gives a fair idea of the Lofotens but not of the Hebrides. J. H. R.

THE HISTORY OF SCARBOROUGH. Edited by ARTHUR ROWNTREE. *London: J. M. Dent & Sons* 1931. 10×7 *inches;* xx+456 *pages; illustrations and plans.* 21*s*

Scarborough found a good historian in Hinderwell (1798), and later a more uneven chronicler in Baker (1882); a compressed narrative of twenty pages is given in *V. C. H.* (1923). A fresh and sounder start has now been made possible by Mr. F. G. Simpson's discovery and excavation (1921–1925) of an Early Iron Age settlement and subsequent Roman watch station on Castle Hill, and by the Place-Name Society's publication dealing with the place-names of the North Riding, by Dr. A. H. Smith. After the Stone, Bronze, and Iron Ages, and Roman epoch came Anglian, Danish, and Norwegian invasions of Yorkshire. Scarborough, long thought of as the stronghold on the steep cliff, is now, since Professor E. V. Gordon stated his new theory in 1925, accepted as Thorgils "Skarthi's" stronghold, which became "a centre of Scandinavian influence from 966–7." The first Norman chapel of Our Lady discovered by Mr. Simpson within the Roman signal station was, according to Dr. Hamilton Thompson (chapter 3 of this book), founded in the eleventh century as a beacon-chapel; but Harold Hardrada had previously so thoroughly burnt and looted the town that "it did not count when the Domesday Survey was made twenty years later." The evolution of the borough, the famous castle, and harbour can be traced in the twelfth century, and is admirably treated in chapters 3–6, chapter 7 carrying on the story for the sixteenth and seventeenth centuries. In Elizabethan days there was no other safe harbour "betwix Humber and Tyne, but onelie Skarbroughe."

Modern Scarborough begins in 1626 with the discovery, by a lady, of the "Spaw Well," and then we have what the editor calls "two centuries of discovery" (1626–1825). The story reads like that of Tunbridge Wells:

> " Let Epsam, Tunbridge, Barnet, Knaresborough be
> In what request they will, Scarborough for me."

The last phase, till 1925, is described as a century of growth, the final item being the bombardment of the town on 16 December 1914, when more than five hundred shells fell over an area of 4 miles. For centuries a shipbuilding port, Scarborough became fifty to sixty years ago the "queen of watering places."

Probably the least familiar matter in this book is the account (chapter 3) of the church and parish. In early Norman times a small church was built for the first time on the ridge west of the castle for the use of the population. It needed considerable enlargement fifty years after its foundation, and at this point its recorded history begins. "The advowson of the church was appendant to the ownership of the castle, and thus in the later part of the twelfth century belonged to the Crown, until Richard I gave it to the abbot and convent of Cîteaux," in 1189.

Mr. Rowntree's is an accurate, thorough, and interesting record, in the making of which he has had the help of specialists such as A. M. Black, R. E. Mortimer Wheeler, R. G. Collingwood, A. Hamilton Thompson, Jean W. Rowntree, D. Montgomerie, A. J. Grant, and others. "Another volume," as the editor writes, "would have to be written to tell of the worthies of Scarborough during the long centuries of life-experiences in borough, castle, church, and harbour.... And the suggested volume would be incomplete unless it told of the rank and file, the toilers of the sea and their wives, the workmen, the flitter girls, and those who ministered to the needs of the visitors." The handsome, noble, and historic town has now a worthy record, well printed and richly illustrated. S. E. W.

THE PLACE-NAMES OF DEVON. By J. E. B. GOVER, A. MAWER, and F. M. STENTON. Part I. (English Place-Name Society, Vol. VIII.) *Cambridge University Press* 1931. 9×6 *inches;* lx+334 *pages; maps* (*in separate case*)

In this volume, for which Mr. J. E. B. Gover is mainly responsible, we have yet another illustration, as in the case of Sussex, of the light that may be thrown on the dark places of history by a scientific study of place-names. Contrary to expectation—for local historians have uniformly stressed the Celtic origins of Devon—the editors have found that the overwhelming majority of the names in this county are of English origin. By what stages and at what dates the English occupied Devon is obscure, though Mr. J. Alexander has contributed some useful papers on the subject to the *Trans. Dev. Assoc.*, in one of which (vol. lxi, pp. 133–6) he contended that the East Devon stage (including Exeter) was completed about 680, the North Devon stage (including a portion of North Cornwall) about 720; the South Devon stage (as far as the Lower Tamar) about 760; and that the last portion of Devon to be conquered was the southern part of Lifton Hundred. The editors are virtually in agreement with this dating, at any rate in the earlier stages, and their reading of place-names seems to confirm it. "The local nomenclature of the county, as a whole, is obviously of a later character than that of any district with which the survey has yet dealt.... It contains an unusual number of names in which the first element is that of a person living in the eleventh century.... The number of female personal names entering into the place-names of Devon is also suggestive of late settlement." The settlement of the county was late, and "a very gradual process spread over all the centuries between the seventh and eleventh, and, indeed, continuing into mediaeval times."

Owing to late settlement one might expect a strong British element in the place-names, but the proportion of such names, excluding river-names—and of the 120 river-names only 35 prove to be definitely of pre-English origin—is less than one per cent. of the whole. This is the most remarkable fact brought out by the present survey—the prevailing English character, the evidence for which is remarkably consistent, even in the Dartmoor area. The Saxon settlers in Devon were obviously not outnumbered by the indigenous inhabitants. The explanation presumably is that, from Devon, thinly inhabited in the Roman-British period, a large number of Celts withdrew to Breton Domnonia a century and more before the Saxon penetration of the south-west. The north-west and

centre of Devon, such is the evidence of names, were occupied mainly by settlers advancing from Somerset, while the south and south-east were reached by men from Dorset. Even among river- and stream-names the English element is more noticeable than in Dorset, Somerset, or Wilts. The Tamar does not mark the boundary between English and Celtic names: "the preponderance of English names on the Bodmin Moors is even more marked than the absence of British ones on Dartmoor." Of British personal names in first elements in place-names there are only ten certain examples. Walla Brook, Walland, and Wallover in Challacombe are among the rare examples of place-names in Wal (=stranger, serf, Briton). Of cases where an OE terminal has been added to an already existing British compound the two chief examples are Dunterton and Breazle. As to the common elements *combe* and *tor*—often adduced as proof of strong Celtic influence—"there is no proof that either word is of British origin."

A few special interpretations may be noted. Devon, like Somerset, has instances of Galmpton, "farm of the gafol men," men paying rent—a reference probably to a particular tenurial system. The river-name "Culm" is given as probably a British word (Cornish, colm) "knot, tie," referring to the numerous twists in the course of the river; Okement, Celt. aku, "swift"; Torridge, mod. Welsh terig, "harsh, violent" stream; Walla Brook (Dart), "stream of the Britons," but Walla Brook (Avon), "spring-fed brook." Lundy is of course "puffin island"; Clovelly "is a very difficult name," and we are left unsatisfied; of many suggestions for Parracombe Blomé's OE pearroc-cumb, "valley marked by an enclosure," is most favoured; Countisbury (Celt. and Eng.) is cunet, "hill," and burh—the arx Cynuit of Asser. The material for early forms is supplied especially by OE charters among the muniments of Exeter Cathedral, OE entries in the Leofric Missal, and Assize Rolls. Domesday forms are much less corrupt than is the case for Sussex, and as a check on them the Exon Domesday is valuable. The present volume covers the first thirteen out of the thirty-three Hundreds, *i.e.* the western part of the county, under which the parishes are dealt with alphabetically; but a beginning is made with a separate treatment of the names of rivers, hills, islands, bays, etc. Of the river-names the number of back-formations (*e.g.* Alphin from Alphington) is comparatively large. S. E. W.

L'ÉVOLUTION MORPHOLOGIQUE DU FAUCIGNY. By ROBERT PERRET. *Paris: Pierre-Henry Barrère* 1931. 9×6 *inches;* 166 *pages; illustrations*

Since 1774, when de Saussure published his 'Voyages dans les Alpes,' the chain of Mont Blanc and the mountains north-west of it have attracted many of the most brilliant geologists intent upon unravelling the complexities of structure and of surface form. Dr. Perret in this volume gives us, in remarkably concise form, the results of their researches in so far as they bear upon the evolution of the surface; and his bibliography contains no less than 190 items. But he has done much more than to pull together and, so far as possible, to harmonize the theories developed to explain phenomena more or less local in character. For the author is himself a geomorphologist of distinction and an intrepid alpinist. All who have studied his magnificent 'Panoramas du Mont Blanc' (1929) will realize how intimate is his knowledge of this group, while his intensive studies, topographic and geological, of the upper basin of the Giffre have given proofs of his capacity for observation and sound deduction. One of these studies incidentally is a reminder that in all this region of Haute Savoie, so attractive to the geomorphologist, there is a special handicap to research, viz. the absence of a detailed official map other than that on the scale 1 : 80,000. Dr. Perret therefore made his own surveys of the district named.

Here he is dealing with a large region of over 400 square miles, contained in a

rough triangle lying between Geneva, the transverse Rhone in Switzerland, and the Mont Blanc summits. Despite the extreme ruggedness of this country, which comprises parts of four major structural zones—the crystalline massifs of Mont Blanc and the Aiguilles Rouges, the High Limestone Alps, the Marginal Chains of the Pre-Alps, and the Molasse plateau—Faucigny possesses geographical unity in virtue of its hydrography; for almost all of it is drained by the Arve and its tributaries in a general transverse direction.

The morphological map of the region presented is the *Carte d'Etat Major*, 1 : 200,000, with coloured overprints by which the author distinguishes erosion surfaces representing six different cycles, apart from a pre-Triassic surface—mostly on the Aiguilles Rouges belt—and large expanses of "structural surfaces," chiefly in the High Limestone Alps, where the sedimentary rocks occur commonly in horizontal recumbent folds. The map further shows the distribution of glacial deposits due to six different stages in the glaciation, and four alluvial terraces which have been traced in the main valleys. Numerous figures in the text and some admirable photographs are further aids to the reader. But in spite of the excellence of all these the larger maps are necessary if one will follow the author completely in the detailed arguments which compose most of the book. Better still however would be a visit to Faucigny with the book in one's pocket.

In a brief review it is impossible to give any adequate impression of the problems tackled and of their solution. They are largely concerned with the history of the courses of the Arve and its tributaries; and they involve questions such as: why the Arve has pushed its source 30 kilometres farther back than the Giffre, and why the longitudinal profiles and other features of the two are so different. In answering these and similar questions the author has to invoke very varied influences. In explaining the trends of valleys structural causes are of course important. Those due to the Alpine folding are, naturally, dominant, but some reaches of valley can only be explained by the trend of Hercynian dislocations. Moreover super-imposition has to be invoked in places. River captures, pre-Glacial and inter-Glacial, are definitely established, and others still more ancient are surmised without hope of confirmation. The effects of successive advances and retreats of the ice are traced from valley to valley. The alternatives of defile and wider basin, so characteristic of Faucigny, are due to no single cause. But each in turn is satisfactorily explained.

The work should have no merely local or regional value, for the sequence of events here described must be paralleled in other parts of the Alps, and all students of geomorphology will be grateful for it. Dr. Perret has written a work essentially for specialists; but for each of these there must be hundreds of others who, cherishing an affection for this region, perhaps the most beautiful and varied of the entire Alpine system, would welcome from his pen a briefer and more generalized account of the origin of its remarkable scenery. A. G. O.

GÉOGRAPHIE UNIVERSELLE. Vol. IV. Europe Centrale. By EMM. DE MARTONNE. Pt. I. Généralités—Allemagne. *Paris: Armand Colin* 1930. 11 × 8 *inches;* 380 *pages; illustrations and maps.* 110 *fr.*

Each volume of this indispensable series is eagerly looked for by students of systematic geography, and none more so than that on Central Europe, for unfortunately to too many the abundant German literature is a sealed book. The name of M. de Martonne ensures a solid physical basis for the treatment of the subject, and allows us to expect a series of beautiful photographs of typical landscapes, but the human side of geography is also given full treatment, and perhaps no chapters in the book will be read with greater interest than those entitled, "*Le Peuplement de l'Europe Centrale: Origines et Evolution*," and "*Nationalités, Etats*

et Groupements," which deal with the changing influence alike of "le milieu" and of "les idées" upon the peoples of Europe, from the Dark Ages down to the present day.

The treatment of Germany necessarily follows somewhat conventional lines, but again a careful balance is struck between the physical and human aspects, the original and illuminating maps of structural and soil conditions being matched by a series of plans of the numerous great cities of which Germany is so justly proud. The economic and commercial conditions of Germany as a whole are dealt with in about forty pages, which leave the reader somewhat unsatisfied, and there might well have been a greater number of the regional economic maps of which Figs. 37 and 44 are conspicuously successful examples; but the fault is in the right direction. The skilful cartographic methods employed, and the excellent execution of the black-and-white maps, are beyond all praise. E. G. R. T.

DIE OSTEUROPÄISCHEN STAATEN: Polen, Litauen, Lettland, Estland, als Staats- und Wirtschaftskörper. By FRIEDRICH KÜRBS. *Stuttgart: Verlag Ferdinand Enke* 1931. 9×6 *inches;* viii+266 *pages; map. RM.*10

This book has been written with the idea of educating the German people to the point of realizing that the principal opportunities for the expansion of German commerce lie in Eastern Europe. Here, in the new republics which have materialized since the war, fresh markets are likely to become available, and the more complete the knowledge and understanding by Germany of these various peoples the more likely is it that firm and friendly economic relations will eventually become established.

The past history of each state is very carefully summarized, throwing much light on the problems in which each is now involved. Thus Poland, in its early days a single nationality, is in its new form compounded of three parts, formerly under the rule of Germany, Austria, and Russia respectively; these having attained to three different stages of development had, at the outset, three different kinds of outlook. Moreover, the effort to attain economic independence has involved a gradual conversion from an almost exclusively agricultural country to one almost equally agricultural and industrial. Lithuania, inhabited mainly by an Indo-Germanic race with an innate desire for freedom, was forced by circumstances too strong for it, into combination with Poland, and so, through the partition of Poland, fell under the jurisdiction of Russia. Its problem now is that, for an agricultural land, it is disastrously lacking in means of transport and also a great part of it is insufficiently drained. The lack of transport could be remedied most quickly by the provision of better roads and road-vehicles, but motor vehicles, low in price and yet strong enough for very inferior and heavy roads, are in great demand and insufficient supply.

Latvia, the largest of the three small republics, is, like Lithuania, mainly agricultural, but its chief difficulty is that, education having attained a comparatively high standard, there is a tendency for far too high a proportion of the population to be equipped for "white-collared" occupations, and this in spite of the numerous excellently organized agricultural courses supplied by the universities.

Estonia suffered less during the war than did the other states which emancipated themselves from Russia and its domestic problems are probably less acute. The principle of cooperation has there greatly assisted agricultural development; moreover, industries such as shipbuilding and cotton-spinning were well established before the war and have since been supplemented by the oil-shale industry. Dairy farming has recently made rapid strides, but there is a great lack of agricultural machinery of every kind. One would suppose that the

chief handicap is linguistic, Finland and Hungary being the only two other countries where this type of language obtains; the difficulty is however being met by the adoption of English as a second language.

The skilful handling of the various political and economic problems should render this work invaluable to any one desiring a practical knowledge of the developments that have been taking place in this part of east-central Europe during the last twelve years. There is a useful bibliography, but the map is confused and inadequate. E. G. W.

STUDIES IN JUGOSLAV PSYCHOLOGY. By JOVAN CVIJIĆ. Translated by FANNY FOSTER. Reprinted from *The Slavonic Review*, Nos. 26, 27, 28. 10 × 7 *inches; 22 pages*

This pamphlet contains three essays from Vol. I of the late Professor Cvijić's 'Govori i članci' (Speeches and Articles), published at Belgrade in 1921. Part of the material is already available in French in his 'La Péninsule Balkanique' (Paris 1918), and there is not much that concerns the geographer directly. Further, the ten years which have elapsed since the first publication of the essays have given the western world some practical knowledge of Yugoslav psychology, and deprived this rather idealistic survey of part of its earlier significance. The pamphlet does however give an idea of the variety of folk included in the new state and of the causes which have led to the development of their characteristics, and thus throws light on the problems which confront it. M. I. N.

TRAMPING THROUGH ICELAND. By D. M. RAMSDEN, M.SC. *Liverpool: Henry Young & Sons* 1931. 7 × 5 *inches; 128 pages; illustrations and map.* 6*s*

Your Icelander is not a walker. When he has business that cannot be transacted on the telephone with a neighbour, he mounts his trusty pony; his boast is: "We would rather ride like kings than walk like beggars." Small wonder then that, when the author and his lady setting out on foot from Akureyri asked the way to the Goðafoss, they were first referred to a hotel and then to a steamboat of that name. And indeed a few years ago they could not have made their walking-tour entirely unaided; sooner or later they would have been faced by a fordless and probably ferryless river. But many bridges have been constructed in recent years as an aid to motor traffic. It is clear from the author's account that most of the motor roads shown on the newest maps are not roads in the accepted European sense, and travelling on them is a painful business even for pedestrians. Beyond the manner of it there is nothing remarkable about the journey described in this little book. The adventurous pair were forced to keep to or near to the usual routes, as they relied for food and lodging on the farms and parsonages whence they were rarely turned away; the kindly (if leisurely) hospitality at these oases can never be forgotten by those who have travelled in Iceland. Once near the Dettifoss and once between Reykholt and Thingvellir they passed premeditatedly a night in the open, short but cold, though this was August and the noonday heat was sometimes uncomfortable. This north and west region of the island is that most traversed by tourists. It would be informative to have another such readable and unpretentious account of a journey along the south-east coast with its greater difficulties. But let the author take a little more trouble with his Icelandic spellings; the national dish is not "skier." J. H. R.

MOORISH TOWNS IN SPAIN. By CECILIA HILL. *London: Methuen & Co.* 1931. 7 × 5 *inches;* xiv + 182 *pages; illustrations.* 7*s* 6*d*

This is a readable, if rather superficial, description of a visit to Toledo, Cordova, Seville, Ronda, and Granada, all places of great historical interest which deserve, one would think, more detailed treatment than the author has thought fit to give

them. The historical background is sketched in somewhat vaguely, with a strong leaning towards romantic situations; but Mrs. Hill set out, as the quotation on her title page shows, with a genuine disposition to be pleased, and it is difficult to resist her enthusiasm, particularly at Ronda, where her descriptive powers are seen at their best. She plans her tour from north to south, which has this advantage, that it brings the traveller first to Toledo, the fighting heart of Spain, although historically the approach should be from the south. The illustrations are excellent, but a map might have been supplied. M. L.

LA LITTÉRATURE ALPESTRE en France et en Angleterre aux XVIII^{e} et XIX^{e} siècles. By CLAIRE-ELIANE ENGEL. *Chambéry: Librairie Dardel* 1930. 10×7 *inches;* xii+288 *pages; illustrations.* 36 *fr.*

It is commonly agreed that the nineteenth century was marked by a general movement towards the appreciation and description of natural scenery. The expression of this feeling has made 'The Alps in Literature' a convenient subject, or peg, for a number of compilers of Anthologies, both prose and verse. It has also furnished material for more or less competent critics from Leslie Stephen and Ruskin downwards. In the latter category we must assign Mlle. Engel a very high place. By research in many libraries in England and on the Continent she has made herself a competent mistress of her subject. Her studies have been both well directed and thorough. And to an exceptional grasp of her material she adds a sympathetic, if critical, appreciation which is shown as fully when dealing with the English writers she has brought under her view as when occupied with her fellow countrymen.

At a moment when some of the zealots of "Alpinism" seem bent on degrading that fine form of travel into a sport for acrobats it is refreshing to come across a foreign critic who is able to appreciate so thoroughly the spirit which was expressed by the early climbers, the fathers of The Alpine Club. But as Mlle. Engel reminds us, not only by the *early* climbers. She quotes Mallory's saying, "A day well spent in the Alps is like some great symphony!"

In other works Mlle. Engel has dealt with the chronicles of modern mountaineering. Her present volume makes no pretence to be a catalogue of climbs. Here she is engaged in an attempt to estimate the claims of the works of writers on the Alps to a place in literature. In the comparison between English and French authors she holds the balance more than fairly. She exhibits, if anything, a tendency to favour our countrymen. For The Alpine Club and its Journal she expresses much understanding and sympathy. Possibly she has realized that the reticent Englishman breaks into spontaneous raptures; while his French comrade reserves his eloquence for what seem to him the right moments.

In Mlle. Engel s pages lovers of the Alps will find a great deal of enjoyment as well as of accurate information skilfully conveyed. Her volume contains a very serviceable bibliography and is illustrated by a number of reproductions of the works of Turner, Cozens, Linck, and Lory. D. W. F.

ASIA

THE PERMIAN OF MONGOLIA. By AMADEUS W. GRABAU. (Natural History of Central Asia. Vol. IV. Edited by C. A. REEDS.) *New York: The American Museum of Natural History* 1931. 11×9 *inches;* xli+666 *pages; illustrations and map. 2 guineas*

The second published volume on the Geology of Mongolia based on the results of the Central Asiatic Expeditions of the American Museum of Natural History under the leadership of Dr. R. C. Andrews is a ten-dollar quarto monograph by

Dr. Grabau on the Permian fossils collected by Professor Berkey and Dr. F. C. Morris, who contribute a chapter on the formation and its geological relations. The area explored by this series of expeditions consists mainly of a pre-Paleozoic foundation, on which were discovered a little Middle Devonian limestone due to the widespread Kuenlun transgression, and some Lower Carboniferous beds which were deposited in a sea that extended across Asia and the North Pacific from the British Isles to the western coast of North America. This Eurasian sea was separated from the contemporary Mississippian sea of the middle of the United States. The widespread uplifts which replaced the marine limestones of north-western Europe by the Middle Carboniferous coalfields extruded the sea from Mongolia. When subsidence recurred red rocks and salt beds were still deposited over western Yunnan, but Central Mongolia, some 350 miles west-north-west of Peiping (Peking), was invaded by a narrow sea in which was deposited the limestone of Jisu Honguer. The discovery of this rock was one of the most important stratigraphical contributions of the expeditions. The fossils were mainly collected by Mr. Morris, and they have been exhaustively studied by Dr. Grabau. The description of one family, the Productidae, is contributed by the late Y. T. Chao, the gifted young Chinese paleontologist, who was the leading authority on the Chinese Carboniferous. His murder by brigands in Yunnan has cut short a career of exceptional promise.

The Permian rocks and their relations are described in a chapter by Professor Berkey and Mr. Morris, who differ in one respect from Dr. Grabau: he considers the unfossiliferous graywackes and slates below the Permian limestones as Upper Palaeozoic; but Berkey and Morris include them in the Sinian and thus refer them to the late pre-Paleozoic; and their conclusion seems most probable from the position of similar rocks elsewhere in eastern Asia.

The fauna of this Permian limestone is somewhat restricted in composition. It includes three determined species of corals, one of Bryozoa, 85 of brachopods, 13 of lamellibranchs, and 18 of gastropods. Many groups are unrepresented and the specimens are described as dwarfed and stunted. Hence the limestone was apparently deposited in a narrow land-locked arm of the sea that was not occupied by a full open sea fauna. The evidence is conclusive as to its Permian age, of about the horizon of the Central European Zechstein, and that the limestone was deposited in a gulf from the boreal Permian sea from which other branches reached Germany and Spitsbergen.

Dr. Grabau has added greatly to the value of this work by having taken the opportunity to summarize the evidence and print lists of the fossils of the Permian rocks of Asia and of parts of eastern and south-eastern Europe and Spitsbergen (pp. 383–536). After his careful statement of the available evidence he proposes a downward enlargement of the Permian System by inclusion of the Uralian Series. He holds that in the Donetz Basin there is an important series of deposits—which he calls the Bakhmout Beds—later than the Middle Carboniferous (the Moscovian) and earlier than the Uralian. He proposes the name Donetzian for the Upper Carboniferous, and he redefines the Uralian as the Lower Permian. The Artinskian, now the Lower Permian, he transfers to the Middle Permian. These proposals are supported by the facts that the Uralian fauna has certainly much affinity with the Permian, and that there is a widespread marked stratigraphical break at the top of the Moscovian, whereas usually the Uralian and Artinskian are practically conformable. There is however much to be said for the retention of the division between the Carboniferous and Permian at its present position between the Uralian and Artinskian. The Uralian beds include the Omphalotrochus, Schwagerina and Productus cora fauna which is markedly Upper Carboniferous. G. Fredericks (*Centralbl. f. Min.*, 1929, B,

p. 549) has recently rediscussed the problem after a careful study of these beds in the Ural Mountains and has pronounced in favour of inclusion of the Uralian in the Carboniferous. That view is supported by a great weight of authority and evidence.

Dr. Grabau's discussion of this Mongolian fauna enables him to support his former illuminating views as to the paleogeography of the Permian and the origin of its fauna from three sources, the Boreal Sea, the Indo-Pacific sea which reached southern Europe across southern Central Asia, and modified remnants of the Carboniferous fauna of Russia. Dr. Grabau adopts extreme views as to the nature of the Permian geographical changes. He accepts Wegener's theory of the westward drift of America away from the Old World, thus producing the Atlantic Ocean, which he says was not in existence in the Palaeozoic; he also transfers the North Pole to Mexico and the South Pole to the middle of the Indian Ocean (at 20° S. and 80° E.), thus assigning a tropical climate to the Polar Regions and Arctic conditions to the Indian Oceans and adjacent lands. It may be observed that he adopts the Upper Carboniferous age of the Gondwanaland glaciation.

Owing to Dr. Grabau's comparative study of the Mongolian and other Eurasian Permian occurrences, the work, in addition to the importance of its new evidence, will be of high value as a work of reference on the Asiatic and East European Permian. J. W. G.

THROUGH THE DRAGON'S EYES. By L. C. ARLINGTON. *London: Constable & Co.* 1931. 9×6 *inches;* lviii+348 *pages; illustrations and map.* 21*s*

The author of this book spent fifty years in the Chinese Government Service, in the Navy, in the Maritime Customs, and in the Postal Service. The map at the end of the volume shows how widely he travelled during this long service. He has further a very considerable knowledge of the Chinese language. The greater part of the book is autobiographical, with such *obiter dicta* and reflections as occasion requires. He led for the most part an adventurous life, and his account of these adventures makes an extremely readable book. Seemingly of the opinion that *virtus laudatur et alget* (he is very free with Latin tags) he neglects the quieter interludes both in the text and in the coloured illustrations, which are all, except two, of Chinese tortures, and extremely revolting. Chance and his profession seems to have led him into restless spots, but the reader might often wish for more of the normal life of a city removed from the disturbed zone. While his reflections are based on a very considerable experience his statements are sometimes apt to be rather sweeping generalizations, as he is concerned more with the definite expression of his opinions than with a judicial summary of evidence. In spite of this, or probably because of it, the result is a thoroughly entertaining and, it need hardly be added, an extremely well-informed book on the relations of foreigners and the Chinese over a most interesting period of Chinese history. Of geography in its narrower sense there is little—perhaps the greatest weakness of the book; it would be much easier to follow the argument if the author had given a little less space to horrors and more to the environment of the people in different parts of China. L. H. D. B.

AUF DEM DACH DER WELT. By W. LENTZ. *Berlin: Deutsche Buch-Gemeinschaft* 1931. 7×5 *inches;* 354 *pages; illustrations and maps. RM.*4.90

The general work of the German Pamir Expedition of 1928 was outlined by Dr. Rickmers, the leader, in the *Journal* for September 1929. The author of this book accompanied the party as a student of linguistics and ethnology, armed with phonograph and camera. After pointing out the interest of the present inhabitants of the oases and valleys to students of the origin of the Indo-Germanic

peoples, he gives in a lively style a general account of his travels and researches. The Pamirs were reached after visits to Samarqand and Bokhara; the main sphere of his activities was the headwaters of the tributaries flowing south-west to the Amu Darya. The author gives a pleasant account of the Tajik people of these valleys, and sets down many of their legends in verse and prose. G. R. C.

ARABIEN. Eine Landeskundliche Skizze. By Dr. WALTER LESCH. (Mitt. der geogr. Ges. in München. Bd. XXIV, Heft I, 1931.) 10×7 *inches;* 154 *pages*

The author has set himself the task of compiling all available geographical information on Arabia, and this sketch is the firstfruits of his labour. He intends eventually to publish a fuller and more complete work on the same lines.

The first part of the work, dealing with geography, geology, climate, flora, and fauna, contains much valuable and, in general, well-documented scientific information. The references include two articles published early in 1931, but a number of important earlier works have been omitted, such as Little's exploration of Makalla hinterland, Macfadyen's work on the Farsan Islands and Asir coast, de Chardin and Lamare's geological studies of South Arabia, and the general discussion on structural problems in the 'Structure of Asia' (edited by J. W. Gregory, 1929). Most of the geographical and geological facts are taken from earlier compilations, such as those of Blanckenhorn and Krenkel, and the more recent work has not, in many cases, been incorporated. The second part, dealing with the Arabs, religion, towns and settlements, communications, and political conditions, is more general in its scope, and while it is a very readable account of the subjects covered it is not sufficiently detailed to be of value for record. The whole work represents an immense amount of intensive study, and the final results when they appear should be an important contribution to the literature of Arabia. G. M. L.

AFRICA

HISTOIRE PHYSIQUE, NATURELLE ET POLITIQUE DE MADAGASCAR. Edited by A. & G. GRANDIDIER. Vol. III. Météorologie de Madagascar. By le R. P. CHARLES POISSON. *Paris: Soc. d'Éditions Geographiques Maritimes et Coloniales* 1930. 13×10 *inches;* 376 *pages; illustrations.* 300 *fr.*

The author states that the foundations of this extensive treatise on Madagascan meteorology were laid by his predecessor at the Antananarivo Observatory, Father Colin, who, stricken with an incurable malaria and worn out by the difficulties of the war period, did not live to bring the work to fruition. We have been struck with the depth of insight disclosed in this work into the various problems of weather and climate in a large tropical island where cyclones and thunderstorms are both formidable manifestations of Nature. The twelve chapters discuss all the usual meteorological elements over the island as a whole and the different parts; but we are given no more than an incidental reference to the physical features of Madagascar or the different belts of vegetation as influenced by climate. It is not difficult to understand the general factors underlying the distribution of rainfall shown in the maps and text. Thus the south-east trade wind blowing on to the mountainous axis of the island brings heavy rain to the east coast all the year round, and the north-west monsoon brings much rain on the north-west coast during the southern summer when the cyclones occur. The driest part of Madagascar is the flat south-west coast where the country is steppe. This is an example of that tendency to desert conditions which is normal in regions under the influence of the trade winds all through the year. The maximum temperature recorded is 111° F. at Morondava on the west coast, and the lowest 14° F.—a considerable degree of frost—high up in the Ankaratra highlands.

The double daily oscillation of the barometer referred to as the "barometric tide" is very pronounced in calm weather as one would expect in the tropics. The incidence of storms in calm thundery weather, when the south-east trade wind falls light, appears often to be governed by the time of the afternoon minimum of the barometer.

Three appendices deal respectively with the influence of the moon on the weather elements, with native weather sayings, and with the history of some destructive cyclones. Data on the relation of barometric pressure and temperature to the phases of the moon are summarized in a very clear diagram—Fig. 54. This shows that at Diego-Suarez at the northern end of Madagascar, at Antananarivo 500 miles southward in the central highlands, and at Fort Dauphin, another 500 miles away, at the southern end of the island, pressure is higher at full moon than at new moon, the difference in the case of Fort Dauphin for numerous lunar periods averaging about 4 mm., and in the case of the other places 2 mm.

The explanation given is that at new moon, when the combined tidal pull is greatest, the atmosphere is lifted, with overflow at high levels and reduction of the surface pressure. At all three places, too, the temperature averages 2° C. lower at full moon than at new, the effect being ascribed to greater tendency to warm north-west winds at new moon in response to the barometric effect. There seems no reason whatever to doubt the reality of the pressure relation which would be quite in keeping with the existence of small lunar tides in the atmosphere. Father Poisson points out that Madagascar is geographically and climatically particularly well situated for showing up any small lunar influences on the atmosphere that may exist, influences that lend no support to the crude popular belief that the moon controls the weather. He also shows that the Madagascar results differ from those in other parts of the world.

The book may be regarded as a standard. It is well printed, but of most unwieldy size, and so loosely put together that the possessor of a copy will soon be obliged to have it properly bound. L. C. W. B.

PANORAMEN AFRIKANISCHER INSELBERGLANDSCHAFTEN. By S. PASSARGE. *Berlin: Dietrich Reimer Ernst Vohsen* 1928 [1931]. 11 × 8 *inches; 16 pages and 25 panoramas. M.20*

The literature of the inselberg is already considerable. Many theories have been put forward, largely by German writers, to explain this hill type, so characteristic of the hot lands of the Earth, and so striking to all who see it for the first time as an isolated dome rising from an extensive plain. Professor Passarge, who has devoted much study to inselbergs in the past, believes that explanations of their origin are still premature for the simple reason that precise data are lacking. These must consist, as he points out in the preface to the Panoramas, in reliable topographic maps, and in geological surveys such as will determine the relative strength of the rocks forming the hills and their environs in resisting chemical and mechanical weathering. And in relation to this latter question it would seem that certain typical hills should be kept under observation in all states of weather with a view to determining the rapidity with which detritus is removed. It should be noted therefore that surveyors and geologists throughout all the inter-Tropical countries are in a position to contribute to the solution of the inselberg problem.

Pending such precise information Dr. Passarge has performed a useful service in publishing these panoramic drawings of African groups of inselbergs. Twelve were drawn by Schulze from fixed points along the Adamaua from Yola to Lake Chad during the Anglo-German boundary survey between Nigeria and Kamerun. Passarge himself contributes one panorama from Adamaua and two from

Bechuanaland, near Palapye and Gabrones. As the reviewer has seen this district he can testify to their excellence. Three views are from Tanganyika Territory, taken from Bornhardt's geological work on that country, while thirteen sketches made round Gondokoro and in Kordofan by Marno are noted as important, because this draughtsman was quite unbiased, being ignorant of all theories as to the origin of the hills he drew. The series forms a valuable document and it will have greater worth still when topographic maps of all these parts of Africa have been made.

In conclusion it may be useful to abstract Dr. Passarge's statement of what he regards as the essential characteristics of inselbergs. These hills rise from true plains, virtually flat, in which the rock is covered only by the thinnest of layers of its own detritus, stony or sandy. The inselbergs may be composed either of the same rock as the surrounding plains or of more resistant rock. They are of all sizes, from isolated knobs a few metres high to single hills hundreds of metres in height or massive mountain groups of considerable area. Their slopes are generally remarkably steep and smooth, and are frequently covered by loose blocks of the underlying rock. The striking break of slope at the foot of the hill is further emphasized by a notch marking the contact of hill and plain; where the inselberg rock is notably the harder this notch is so sharp that "the hand can just be inserted." But sometimes a gently sloping apron of fine debris forms the contact, as in Kordofan. Inselbergs are sometimes surrounded by a "hill-foot hollow" on the plain which may be 20 metres deep.

Such, in Professor Passarge's view, are the leading features of the "island hills" to which the German language has given their graphic name. As an almost universal element in the landscapes of hot countries, the inselberg would seem to invite widespread cooperation in the attempt to solve the problem of its origin.

A. G. O.

KENYA WITHOUT PREJUDICE. By H. O. WELLER. *London: "East Africa"* 1931. 7×5 *inches;* xii+162 *pages; map.* 5*s*

Mr. Weller's attractive little book, though it contains chapters on such controversial topics as the Settler, the Indian, Education, and the Church, conscientiously retains its impartiality. It will be valuable as a reference book, and has some useful advice to young men about to settle in Kenya. The best chapter is the first, a condensed history of Kenya and Tanganyika during the past century.

H. P. W.

LE MAROC. By JEAN CÉLÉRIER. *Paris: Armand Colin* 1931. 7×5 *inches;* 216 *pages; diagrams and maps.* 10 *fr.* 50 *c.*

LE MAROC. By AUGUSTIN BERNARD. (Seventh Edition.) *Paris: Félix Alcan* 1931. 9×6 *inches;* viii+482 *pages; maps.* 60 *fr.*

Both books under review have this much in common that they are valuable systematic treatises written by well-known authorities; but whilst the larger work, which treats both the geographical and historical aspects, is a completely revised edition of a well-known classic first published in 1913 and has now reached its seventh edition, the smaller volume is a purely geographical and more popular work, as it is specially written for the geographical section of the Armand Colin collection of books which is analogous in plan with our Home University Library.

M. Célérier's book, after an introduction on the relief, climate, vegetation, and sources of water, is then divided into two main parts. Part I in six chapters gives careful and intimate studies of native life in the four great natural regions which comprise Atlantic Morocco, the high mountains, the Saharan border, and the

plateau steppes of Eastern Morocco. Part II in seven chapters discusses general economic problems such as immigration, ports, communications, water power, agriculture, mineral wealth, industries, and trade.

The first edition (1913) of M. Augustin Bernard's excellent work (*vide* review, *G.J.*, vol. 40, pp. 561–2) was divided into four parts. Parts I and II dealt respectively with geographical and historical conditions. Part III contained a discussion of the social, religious, and economic life of the native, while Part IV traced the development of European influence in Morocco from the Middle Ages until the establishment in 1912 of the French Protectorate. It is obvious that such an important theme as the "French Protectorate" would in time need fuller treatment than was possible in a single chapter, and so in later editions a new part was added to deal with this subject. A comparison between the sixth (1921) and seventh editions shows that much progress has been made in reducing the areas of insecurity, more new roads and railways have been constructed, while commerce and the exploitation of mineral wealth have advanced; so that it is Part V that has needed most revision.

Since 1921 the total length of the first and second class roads in French Morocco has increased from 2500 to 3500 kms. and from 680 to 2500 kms. respectively, whilst other routes, strategic and economic in status, have kept pace with the penetration of the mountain zones. All efforts are now being made by the C.F.M. to complete by 1935 the Fez–Oudjda line, whose construction, apart from the difficulties of the terrain, was interrupted by the Abd-el-Krim rebellion. Its completion will mean not only the existence of a Casablanca–Tunis arterial normal gauge route, but will foster the exploitation of mineral wealth in Eastern Morocco.

A methodical inventory is being made of all waterfalls, the seasonal flow of streams, and the possibilities of all underground water supplies, whilst serious attention is being given to the large-scale production of electric power. Halfway between Oudjda and Berguent lies the newly discovered Djerada anthracite basin. There is however reason to believe that a vast concealed coalfield, linking up with the Kenadsa deposits, exists under the stony plateaus of the Upper Guir and Ziz.

Both books have very complete bibliographies, but are without indexes: some of the black-and-white maps might be clearer. In M. Célérier's book the six maps and three graphs are arranged in the text, but in H. Bernard's work the five maps, four of which remain unchanged from the first edition (1913), form a folded sheet at the end. R. E. P.

NORTH AMERICA

ARCHAEOLOGY OF THE ARKANSAS RIVER VALLEY By W. K. Moorehead. *New Haven: Yale University Press; and London: Humphrey Milford* 1931. 11×8 *inches;* x+204 *pages; illustrations and sketch-maps.* 18*s*

In this volume the author has collected together a number of observations and explorations, generally of a superficial character, made by himself and others in the valley of the Arkansas River and its affluents, the Canadian and Cimarron. All this material is presented in a rather disjointed fashion not too clearly arranged, which is not helped by the absence of a map of the river valley, a grave defect in a work of this kind. It is however only fair to say that the author in his preface is careful to point out that his object is to indicate the importance of the field, and to suggest future and thorough exploration.

The great tributary of the Mississippi, the Arkansas River, is 1500 miles long, and in the extent of its watershed ranks sixth in the list of the rivers of the United States. It rises in the Pueblo Cliff Dwellers' cultural area, passes through the

old buffalo country, and by a region of caves and rock shelters finally reaching the Mississippi in the Mound Builders' region. In its course it probably touches as many Indian stocks as the Missouri, and therefore suggests considerable possibilities for archaeological research, and that it may have played a very important part in pre-Columbian times. It is suggested that six or seven different cultures can be recognized, four at least quite plainly, *e.g.* the Mound Builders, the Ozark Bluff Dwellers, the Basket Maker Stock, and the Texas Panhandle culture. The Basket Makers of the Cimanon River region were probably the most primitive of all the prehistoric stocks. An interesting feature of this culture is the presence of numerous petroglyphs. They are mostly engraved, only a few being painted, and represent men, houses, buffaloes, etc. The Texas Panhandle is characterized by many remains of stone buildings, and their relation to the Pueblo culture to the west is discussed. Its responsibility for the Panhandle stone building is controverted on the grounds of difference of architecture and absence of characteristic pottery. The interesting and important, though little-studied subject of migration is touched upon in regard to the Caddoan people who inhabited a very extensive triangular area west of the Mississippi from the mouth of the Missouri to Vicksburg, and whose culture was characterized by an enormous number of low mounds, in the aggregate more numerous than all the mounds of the true mound-building people combined. It is argued that they came from the south, and not from the north-west, the thickly populated region of Yucatan and South Mexico affording a more likely swarming ground. On the other hand the view is favoured that the Pueblo Cliff Dwellers migrated in the opposite direction from north to south. The author has certainly attained his object by pointing out where further and more intensive investigation is desirable, and in making useful suggestions which, if acted upon, should lead to important results. There are illustrations of artifacts, pottery, and petroglyphs, and several sketch-maps. Some of the photographs of sites are not too well reproduced.

E. A. P.

THE NEW NEWFOUNDLAND. By J. R. SMALLWOOD. *London: Macmillan & Co.* 1931. 8×5 *inches;* xvi+298 *pages; illustrations and map.* 12*s* 6*d*

Newfoundland, with her 43,000 square miles, her population of 260,000, her 1141 schools, and her 16 per cent. illiteracy has made wonderful strides during the last twenty years. The author, himself a Newfoundlander, endeavours to portray the progress of Britain's oldest colony, so rich in her natural resources. But he seems to have little or no first-hand knowledge, and apart from a brief press extract in one of the appendices no mention is made of the salmon industry, although in 1930 over two million pounds of frozen salmon were exported from Newfoundland and Labrador to the English market. No mention is made of the cod-liver oil industry, nor, more surprising still, of the seal fishery, which employs so many Newfoundlanders for a period of the year. Such interesting developments as the halibut fishery and the blueberry industry for which there is a thriving export trade to Canada and New England are perhaps unknown to Mr. Smallwood. The problems of the cod fishery, which is the basic industry of the country, are touched upon lightly and without appreciation of the fact that Newfoundland is losing her markets to Iceland and Norway, because, unlike her rivals, as yet she has not imposed a rigorous standard upon the grades of fish exported, thus insuring quality to the consumers. The chapter on Labrador, with enormous estimates of its potential value, is as foggy as its coast.

In dealing with the pulp and paper industry the author has armed himself with interesting statistics. Lord Northcliffe was the pioneer in this great Newfoundland industry, and from January 1910 onwards the paper used in the pro-

duction of the Northcliffe publications has been manufactured at Grand Falls to the total of 1,250,000 tons. After the war a similar venture was undertaken by Messrs. Armstrong Whitworths on a vast scale at Corner Brook on the western coast of the island. Unfortunately the scheme came to grief, and the property and the concessions were disposed of to American interests who are reaping from it a rich reward. In 1930 they produced 167,000 tons of paper. Apart from the fact that employment is given to many Newfoundlanders by the pulp and paper industry, we are left in ignorance as to the revenues received by the Government or as to the laws governing reafforestation.

Rich in fish and timber, Newfoundland has as yet done little more than to scratch at the surface of her mineral wealth. One of the largest hematite mines in the world is operated at Bell Island within 12 miles of St. John's, the capital of the island. In 1929 the export of iron ore from this one mine amounted to 1,500,000 tons, Germany taking half and the residue being shipped to Sydney, Nova Scotia. An interesting chapter deals with the more recent development of Buchan's Mine in the interior of the island, where zinc, lead, and copper are produced under joint English and American interests.

Of late years Newfoundland has paid attention to the value of the American and Canadian tourist trade, and, with an eye to popularizing the colony as a tourist resort, a modern hotel has been constructed at St. John's with Government aid, and railway facilities have been greatly improved. In 1929 8300 tourists visited the island, and on the Canadian reckoning that on an average each tourist spends $100 during his sojourn, the country is profiting from this development.

It is a matter of regret that a book which purports to give a comprehensive picture of Newfoundland and which applauds a chosen few among her politicians should omit reference to men of distinction such as Sir William Allardyce, Sir Edgar Bowring, and Sir Wilfred Grenfell, who in their respective spheres have given generous aid to the well-being of the colony. In spite of its excellent illustrations, its map, and its index this book falls short by many fathoms of doing justice to the interests of Terra Nova. G. B.

AMONG THE ESKIMO OF WALES, ALASKA, 1890–93. By H. R. THORNTON. *Baltimore: John Hopkins Press* (*London: Humphrey Milford*) 1931. 9×6 *inches;* xxxviii+234 *pages; illustrations and map.* 18*s*

Edited jointly by his widow and his brother this book is in the nature of a memorial to the work of Mr. H. R. Thornton, who went in 1890 as a pioneer missionary and school teacher to Cape Wales, Alaska—the westernmost point of the North American Continent which juts out into the Bering Strait. After a preliminary year's work Mr. Thornton returned to the United States to lay before the Government a protest against trading whisky to the natives, and to gain repeal of the law against trading breech-loaders to the natives in view of the danger of starvation among them. He was also among the first to advocate the domestication of reindeer in Alaska and the protection of walrus herds against extermination by the white man. With little encouragement from the Government he set forth again to Alaska to continue his work among the Kinik-Mete tribe of Eskimo with the help of his newly married wife. In the course of his second year's sojourn at Cape Wales he was murdered by a drunken native who at point-blank range discharged a whale-gun at him through the door of the mission house.

The volume, which is lavishly illustrated, records in sixty-four sections Mr. Thornton's impressions of the Eskimo, their habits, customs, and language, while attention is also paid to the natural history of the region. His companion in Alaska, Mr. W. T. Lopp, subsequently devoted his life's work to the native

welfare of that country, holding between 1910 and 1923 the position of Chief of the Alaska Division of the United States Bureau of Education, and it seems a great pity that the material which has gone to the making of this book should not have had the benefit of his expert editing. Mr. Thornton was a novice among the Eskimo and laid no claim to a scientific training. Thus the book falls short of any precise scientific value, and its interest lies mainly in the picture of Alaska under early American administration and in the graphic description of daily Eskimo life.

It is a terrible indictment of the early administration that the American whaling fleet, without hindrance from the Government, conducted a profitable side line by paddling crude alcohol to the Eskimo, thereby completely and irretrievably demoralizing them—the old story of the South Seas re-enacted in the Bering Strait.

The student interested in comparing the customs of the Eskimo tribes distributed from Alaska to Greenland will probably conclude from a perusal of Mr. Thornton's material that in spite of their continent-wide distribution the Alaskan Eskimo differs little in language as in culture from his cousins 5000 miles farther east on the shores of East Greenland, though morally and physically there is little left in common between them. The editors have provided a poor map and no index, and they have allowed zeal rather than discretion to guide their copious annotations to an interesting narrative. G. B.

CENTRAL AND SOUTH AMERICA

L'ANCIENNE CIVILISATION DES BARREALES DU NORD-OUEST Argentin. (Ars Americana II.) By S. DEBENDETTI. *Paris: G. van Oest* 1931. 14×11 *inches;* 56+lxviii *pages; illustrations and sketch-map.* 350 *fr.*

This is the second monograph of the Ars Americana series, and is published in the same form, and illustrated with the same sumptuousness as the first on the Archaeology of the Amazon Basin, recently reviewed in the *Journal*. It consists essentially of sixty-eight plates, all of which, except the first two, illustrate the pottery and objects of stone, bone, and metal discovered in pre-Hispanic cemeteries, on two sites—La Ciénaga and La Aguada—in the Catamarca province of North-West Argentine. No less than fifty-five of the plates are devoted to the pottery, eight of them coloured. The production of these illustrations merits high praise. The plates are preceded by a short introduction in which a general account is given of the site and exploration, with illustrations in black and white of the designs ornamenting the pottery. The first two plates show the nature of the country where the sites explored are situated. It is now a desert region, characterized by dead forest to which the term Barreales is applied. There was nothing on the surface to indicate the archaeological treasures buried beneath it, and brought to light by exploration during the years 1925–29. Some five thousand specimens were obtained, now in the private collection of Sr. Barretto, under whose care the archaeological expeditions were carried out.

All the pottery is of a funerary character. It is very varied and the types differ fundamentally from those already known to Argentine archaeology. It shows characteristics of style restricted to a single culture and a single art. Most of the pottery is black, but some is coloured. In some cases the outer surface is polished, probably with graphite, before firing. The decoration is geometrical, zoomorphic, and anthropomorphic, the latter highly stylized. Modelling is shown in vases of animal and human form. This ancient pottery must be assigned a high place in the scale of values of the discoveries made in the Argentine. "The material is so fine, the walls so thin, the firing so perfect that many specimens when struck

sound like porcelain. We cannot help admiring the perfection of form, the regularity of the technique and the accuracy of execution, when we remember that these ancient potters were unacquainted with the wheel." Stone vases are ornamented with anthropomorphic forms in relief. The metal objects, few in number, are of copper and gold, the former cast, the latter laminated.

There is a map of the Argentine showing the situation of the sites explored, a detailed description of the plates, and a Bibliography. The only criticism to be offered is of the price, which must make the volume prohibitive to almost all except public bodies. E. A. P.

IAERLYCK VERHAEL VAN DE VERRICHTINGHEN DER GEOCTROyeerde West-Indische Compagnie, in derthien Boecken. By JOANNES DE LAET. Eerste Deel. Boek I–III (1624–26). Edited by S. P. L'HONORÉ NABER. *'s-Gravenhage: Martinus Nijhoff* 1931. 10×6 *inches;* xxx+186 *pages; illustrations and maps*

In 1621 the Dutch merchants who traded with the coast of North and South America formed a West India Company. They obtained a charter from the States General on June 3 of that year. This charter gave them rights with regard to that part of the world situated to the West of Africa, the West Coast of Africa included, similar to those given by the charter of the East India Company to the merchants trading with the East.

The West India Company had a faithful chronicler of its heroic days as the East India Company had its Valentyn, the author of 'Beghin ende voortgang,' and its standing counsel Pieter van Dam. Joannes de Laet, of Leiden, who began by being an employee of the Company and afterwards succeeded in becoming one of its directors, has in thirteen books, each book representing one year, described the acts and deeds of the company from 1623 to 1636. His work, called 'Iaerlyck Verhael van de Verrichtinghen der Geoctroyeerde West-Indische Compagnie' (Annual Description of the Acts of the Chartered West Indian Company) appeared in 1644. It was translated into Portuguese and appeared in two volumes in Rio de Janeiro in 1916 and 1925. A new edition has now been prepared by the Van Linschoten Society of the Hague, Holland, edited by S. P. de l'Honoré Naber, who has written a preface to the present volume which contains the first three books of the 'Iaerlyck Verhael.'

De Laet was fortunate in having the whole of the records of the Company at his disposal which he could use and quote at will. He was still more fortunate in becoming an absolute authority by having all records destroyed after he had used them, they being in his opinion no longer of any use, so that the present generation has to rely entirely on de Laet's version for knowledge of the historical development and acts of the Dutch West India Company in the first half of the seventeenth century. The editor of the present edition reminds us that in an earlier work called 'Nieuwe Werelt ofte Beschryvinghe van West-Indien ' (New World or Description of West India), de Laet aimed at doing for the West Indies what Jan Huyghen van Linschoten had done for the East Indies in his 'Reysgeschrift' (1595), by giving a series of sailing indications and coast descriptions which however contain here and there golden grains of historical events. The 'New World' went through two editions and was translated into Latin and French.

With these two works de Laet did for the West, without assistance and alone, what van Linschoten, Valentyn, and van Dam had done for the East. His 'Iaerlyck Verhael' is based on his own researches of the records which are no longer in existence and is difficult to check. It is prefaced by a copy of the charter of the Company with its additions and a list of the Directors of the Company from 1621–1636. The story itself is strictly chronological and written in a neutral

style which thereby loses much in vivacity. It misses individuality and deprives the reader of an opportunity to learn anything of de Laet's own character. The editor deplores this, as so little is known of the author, who must have been a person of great erudition. Besides being a Director of a mercantile enterprise he was chosen to be a member of the Synod of Dordrecht (1618–1619). He corresponded—as appears from letters in the Leiden Library—with the most learned men of his time. As geographer he wrote a great number of volumes of Elzevier's geographical library.

The first edition of the 'Iaerlyck Verhael' was printed in a Gothic type. The present edition, to the contrary, is clearly printed in Latin characters, while the editor has improved the facility of reading it by dividing the text from time to time in new paragraphs and here and there leaving a blank space. He has also compressed the titles of the chapters where these seemed too long and voluminous, while the enumeration of the constitution of the various fleets has been curtailed. The edition is illustrated with well-reproduced maps, while a portrait of de Laet is bound opposite the title page. The Van Linschoten Society deserves our thanks for having added another interesting work to the series of its handsomely produced and carefully edited publications. W. R. B.

LAGOONED IN THE VIRGIN ISLANDS. By HASEL EADIE. *London: George Routledge & Sons* 1931. 9×6 *inches;* xii+444 *pages; illustrations and sketch-map.* 10*s* 6*d*

The author in her prologue claims her book as the creation of a wanderer and lover: she denies that she is poet or scientist. Unless a writer be something of a poet or a scientist, the recounting of experience may be too difficult. Miss Eadie spent a short time on one of the islands of the Virgin group. These islands lie to the northward of Barbadoes and the better-known islands of the Leeward arc. The scanty white population of the group is concentrated in Tortola, which is mountainous, cultivated for sugar, and surrounded by a coral reef. The word "lagooned" is then immediately misleading, for here it was that the author dwelt in a building well above sea-level. But "ylands" and "pyrates" are worse.

It is not that the author has nothing to say. It is that the book has no discernible structure and is in fact a series of trivialities festooned between a great number of interesting quotations and some bad verse. The author was really interested in the black people and has indeed a sensitive sympathy with all things natural. For some reason she thought that this was unorthodox. To recapture the interest of the orthodox, perhaps, she wrote her book in a precious journalese that few will be able to stomach. "Often, like a whisper breathed in a dream, I hear the word 'Tortola,' and there sounds through the stillness the night chant of the Bush and the song of the Virgin seas. The veil is lifted and figures dim and dream-dark troop down the vistas of the past, beckon and vanish. TORTOLA! Isle of turtle-doves and twilit dreams! . . . 'yland' of enchantment lost in the Caribbean Sea!—for ever weaving spells beneath the sun . . . beneath the moon . . . and the paling stars. . . ." M. A. S.

AUSTRALASIA AND PACIFIC

AN ATLAS OF POPULATION AND PRODUCTION FOR NEW SOUTH WALES. By MACDONALD HOLMES. *Sydney: Angus and Robertson* 1931. 9×6 *inches;* xii+70 *pages* (*text*) *and* 31 *pages* (*maps*)

Maps are indispensable to the clear definition of many facts and relationships, especially in economic and demographic geography; but we mistrust the statement quoted by Professor Holmes that "in geography we may take it as an axiom

that what cannot be mapped cannot be described," which seems to imply that the map can always be constructed to do the work better than the written description. The fact that special maps must usually be of a kind suitable for reproduction by reasonably cheap methods, sets limits upon the technique employed. In this atlas of New South Wales some of the maps and diagrams, *e.g.* maps 21 and 30, and diagram 1, seem to have had more thrust on them than they can comfortably deal with, for they have little graphic value and are even confusing. Of the other maps in this collection the most successful perhaps are those based on the accurate placing and spacing of dots, but these must be very laborious to prepare. The text and the maps together supply an up-to-date account of certain aspects of the economic geography of New South Wales, but leave a sense of incompleteness when the book has been studied from cover to cover. In the midst of generalized statements, logical deductions and summary maps, one misses the details of the human element, of the real driving force, by which the whole composite area works and lives. E. W. S.

FIJI AND THE FIJIANS, 1835–1856. By G. C. HENDERSON. *Sydney: Angus and Robertson* 1931. 9×6 *inches;* xii+334 *pages*

Students of matters both historical and anthropological dealing with the Pacific will put this book down with feelings of regret. The author has had access to the hitherto unpublished Journals of Thomas Williams, famous as a pioneer missionary in Fiji, and joint author with James Calvert of the best of the early accounts of native life. In addition he has been able to draw on numerous documents preserved in the archives of Missionary Societies in London, together with other records now in Government hands. As a narrative of missionary history over the years 1835–56 the author's work is of value, since he brings together a mass of details hitherto inaccessible, whilst his résumé of references scattered through the published accounts of the early voyages affords a ready reference. One feels however that in view of his opportunities of access to Williams's Journals, and other documents, he would have done a greater service to science had he been content to reproduce Williams's Journals in their original form, with scientific notes. His title is somewhat misleading, since it is actually that used by Williams and Calvert in 1858, whose work presents a highly valuable account of both the natives and the historical incidents arising from the early influence of the whites, and affords what is practically the only reference work on the Fijis at this early date.

The opening chapter of Mr. Henderson's book is devoted to a criticism of Basil Thomson's remarks on missionary policy, published in his standard work 'The Fijians,' which is, without doubt, the best work of modern times: the matter is nevertheless of small interest. Mr. Henderson is however equally impartial to the doings of the missionaries and his remarks are unbiased. The reproduction of many of the numerous plates is by no means good, and the several maps and charts are mostly quite illegible. The plates should have been considerably revised, since those dealing with local scenery and native types are of no great interest, whilst the remainder are taken from Shipley's fine folio of engravings published in 1851. The inclusion of a portrait of a Chief of the New Hebrides is rather out of place, particularly as he is garbed in a well-fitting European suit, complete with tennis shoes. The author's use of certain names, both of people and localities, might well have been amended: one does not to-day speak of "Tonguese" when referring to the people of Tonga, whilst "Tonga" has long superseded Cook's "Friendly Islands" as a name for the whole group. Again, "Bellingsgauzen" may be the correct Russian form, but "Bellingshausen" is universally adopted by students as the name of this

celebrated navigator, whose only published account appeared just a century ago, and of which available copies are so rarely met with.

It is a matter of regret that a work dealing mainly with Thomas Williams has not included a portrait of this well-known missionary. The author adds a short, and by no means complete, bibliography, which is somewhat confusing in its conception and lacks alphabetical arrangement. Although several references are made to William Lockerby's Journal, published by the Hakluyt Society, the author is apparently unaware of other and similar private journals of seafaring men, since these respective authors lived a more or less native life, and their views therefore are unaffected by the missionary point of view. I refer more particularly to William Endicott's Narrative, 1829, published at Salem, Mass., in 1923; to Hadfield's 'Cannibal Jack,' 1843, published in London in 1925; and lastly to Carey's 'Narrative of the Wreck of the *Oneo*, South Sea Whaler,' 1825, and issued in book form at Nantucket, U.S.A., in 1922. Although these comparatively unknown publications are mostly anterior to the writer's researches, they are of value in affording an insight into the early advent of Europeans to the group; altogether they are of considerable importance, and strongly influenced the actions recorded by Mr. Henderson. H. G. B.

POLAR REGIONS

REPORTS OF THE GREENLAND EXPEDITIONS OF THE UNIVERsity of Michigan (1926–31). WILLIAM HERBERT HOBBS, Director. Part I, Aërology. Expeditions of 1926 and 1927–29. S. P. FERGUSSON, Editor. *University of Michigan Press* 1931. 11 × 8 *inches;* x + 260 + xxiii *pages; illustrations and maps*

These expeditions have succeeded in obtaining a remarkable series of observations of the upper wind by means of pilot balloons in West Greenland, mostly at Mount Evans, about lat. 67° N., long. 51° W. The observations were obtained almost daily, even in the winter months. The results are set out in an able manner in the publication under review, the greater part of the book being occupied by the individual ascents. There is a valuable introduction by Professor Hobbs, giving an illustrated description of the practical work and also some discussion of the results, including diagrams of means for various seasons. The latter part of the volume includes a few soundings of upper air temperature, and a large number of cloud observations, illustrated by a fine set of photographs.

On the average the wind is south-easterly at heights below 3 kilometres, southerly from 3 to 5 kilometres, and south-westerly from 5 to 8 kilometres. Simultaneous observations made in East Greenland by a Norwegian expedition for about six weeks in the summer of 1926 are also published for comparison. It is to be hoped that more such simultaneous observations may be made in future at all seasons, as it is only by such means that the amount of cold air flowing off the inland ice can be estimated. An increase with height of the west component of wind velocity is a normal feature over a considerable part of the globe, and a prevalence of easterly winds in the lower levels in Greenland is to be expected owing to the low pressure to southward.

A series of observations of this kind may be regarded both as a study of local winds in an interesting district and as a contribution to the larger problems of atmospheric circulation. The latter aspect is of course more important, but it is a mistake to magnify the effect of one particular region. The area of Greenland is only about one-twentieth of the total area north of latitude 60°, and is small when judged on the meteorological scale. It is claimed that "strophs" from the "glacial anticyclone" (*i.e.* unusually strong outflowing winds) are responsible for

the subsequent development of storms on the shipping lanes. This cannot be regarded as established, and it may be argued with rather more justification that the "strophs" are themselves often caused by cyclonic depressions to southward or westward. This conclusion is supported both by the daily synoptic charts, which now include the Atlantic and South Greenland, and also by the descriptions given of the "strophs," in which emphasis is laid on foehn clouds to eastward and on the relatively high temperature. A true foehn wind is part of a large current which is forced over a mountain range and owes its warmth to compression during its descent, and is thus radically different from a cold down-slope wind falling under the influence of gravity.

It is no doubt tempting to try to explain as many atmospheric phenomena as possible by means of one factor, such as the flow of cold air off Greenland, but such attempts have never yet succeeded in meteorology, and are not likely to, owing to the number of different factors acting. The real value of scientific expeditions such as these consists of the filling up of gaps in the growing body of our knowledge of the atmosphere, which in course of time must lead to a greater understanding of the difficult problems involved. Professor Hobbs and the various members of the expeditions are to be congratulated on having obtained this valuable set of data. C. K. M. D.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

WILD BEASTS TO-DAY. By HAROLD J. STEPSTONE. *London: Sampson Low, Marston & Co.* [N.D.] 9×6 *inches;* x+254 *pages; illustrations.* 12*s* 6*d*

It is a particular pleasure to review a book that deals with the preservation and not the killing of animals. Mr. Shepstone has made a careful study of the subject and has secured his material by personal observation. He gives an account of the world's leading zoological gardens, the catching, transportation, and doctoring of wild animals, the rearing of them in farms, and the work of conserving the rarer species in parks and reservations. He has visited the chief zoos in Europe and America, and gives an excellent account of their more striking features and many incidents in the lives of their inhabitants. Of special interest is his chapter on the doctoring of wild animals. He tells us how the elephant has its feet trimmed and the tiger its claws cut. The specialist has sometimes to be called in: it may be to give an anaesthetic to a rhinoceros or extract a tooth from the jaw of a hippopotamus or remove a cataract from an ape's eye. We learn much of how animals are trapped and transported, what are the most valuable kinds, and what they cost.

Persons interested in the preservation of wild creatures are certain to be pleased with his chapters on farms. There is no better way of saving animals from extinction than by making them useful in the live state. Once their carcases have a marketable value, whether for tusks or horns or hides or oil, their decline is certain and their disappearance highly probable. But make their live bodies a remunerative possession, and the danger of extinction practically disappears. The Indian elephant is safe because he is made useful for haulage; the African elephant is on the road to extinction because nothing is wanted from him but his tusks. It may seem a paradox, but it is a fact, that if animals are kept alive for no other purpose but killing that will be of value in preserving them from extinction. The preservation of our common fox for hunting has meant its survival in England. For if the farmers were not paid to endure him they would long ago have sent him to join the wolf. Hence if we wish to preserve wild life we should encourage all activities that aim at the usefulness of the animal while alive. The author describes many of such activities. There is the farming of the African ostrich for feathers,

an industry which will insist on the preservation of the ostrich so long as the demand for feathers remains. Then the alligator is farmed for its hide in America, the turtle for soup-making in Japan and the West Indies, snakes for making anti-venom in Brazil and South Africa, and even the lion is farmed in California for the requirements of the films. The farming of furs is a growing industry. There are three hundred fox ranches in Prince Edward Island alone; there are scores of skunk farms in the United States and Canada; there are over a hundred mink ranches in the States and probably another fifty in Canada.

The author tells the story of the American bison and how it was saved when on the verge of extermination. There is much of interest on the slaughter of the whale, which, like the great pachyderms of the land, the elephant, rhinoceros, and hippopotamus, is rapidly repeating the history of the bison. Lastly there is an account of the National Parks of Canada, the game reserves of Africa and the splendid sanctuaries of the United States. It is a pleasure to find all this matter dealing with conservation brought before the public in a delightful manner. The book is not only full of instruction, but decorated with charming illustrations. It is a gratifying addition to a neglected subject, and a timely reminder of how much can be done to preserve for the benefit of future generations some portion of what we have enjoyed. R. W. G. H.

ENGINEERING GEOLOGY. By H. RIES and T. L. WATSON. (Fourth Edition.) *New York: John Wiley & Sons* (*London: Chapman and Hall*) 1931. 9×6 *inches;* viii+708 *pages; illustrations and maps.* 25*s*

It is a moot point how far the study of geology should be included in the curriculum of the engineering student. Some knowledge of the nature and composition of the materials forming the Earth's crust is, without question, essential, but in much engineering practice it suffices if this knowledge is strictly practical, confined to an understanding of the behaviour of minerals and metals when subjected to stress and their durability under the action of time and weather. The theoretical principles of coordinated geology have not infrequently been looked upon as a refinement, superfluous from the point of view of the design and execution of engineering structures. On the other hand, much is to be said for a systematic study of the subject as a whole. It widens the outlook, gives a more comprehensive and exact knowledge, and affords a clearer perspective of the framework within which man strives to adapt the forces of Nature to his own ends. Yet a science which covers so much ground, physical, chemical, and historical, cannot adequately be treated within narrow compass, and hence the difficulty of finding some line which can be drawn so as to include all that is essential and leave out whatever is unnecessary.

Such is the problem which Dr. Ries and Dr. Watson have endeavoured to solve in their book, which embodies the teaching they have given orally to students at their respective universities in the United States. Apparently they have decided in favour of wide comprehensiveness as a guiding principle. Indeed, in turning over the 700 odd pages, one finds some strikingly unexpected inclusions. River hydraulics, wave dynamics, and littoral drift are matters which are more usually found in treatises *ad hoc*, and their discussion in the present volume necessarily suffers from severe compression. The explanation of the flow of streams round bends, for instance, is somewhat superficial, and ignores the important contribution of Professor James Thomson to the subject. The same remark may be made in regard to wave action and the researches of Professor Luiggi.

However, conceding the question of catholicity, it must be admitted that the book gives a very fair general résumé of the principal facts and the available data.

It has been carefully compiled and is very fully documented, chiefly, and indeed with relatively few exceptions, from American sources. The Water Supply Papers of the U.S. Geological Survey are copiously cited. The photographic illustrations, which are excellently reproduced, are nearly all of examples to be found in the North American Continent. This enables the book to make a special appeal to the American student.

The work is now in its fourth edition (an effective tribute to its popularity) and the scope of the contents is probably within the knowledge of many. To them, it need only be said that the additional matter included in the present edition is a chapter on the geology of reservoirs and dam sites, rendered desirable by the great importance of Water Supply Engineering and its outstanding development in recent years.

For others who are not conversant with the older editions the following brief summary of the contents may be useful. Chapters 1 to 4 deal with mineralogy and the general characteristics of rocks; chapters 5 and 6 with surface and subsurface waters; chapter 7 with landslides and subsidences; chapter 8 with wave action and shore currents; chapter 9 with lakes; chapter 10 with glacial deposits; chapter 11 with reservoirs and dam sites; chapters 12 to 18 with various materials of structural and industrial value, and the last chapter with historical geology. There is an appendix on geological surveys. The unfortunate omission in the table on p. 4461 of a decimal point, though obvious on examination, may mislead the young student. B. C.

CARTOGRAPHY

ATLAS CLASSIQUE. By JOSEPH HALKIN. *Namur: Maison d'Editions ad. Wesmeel-Charlier.* 14 × 10 *inches;* 28 *pages and* 40 *plates.*

The title of this Atlas, no doubt well understood in Belgium, is very misleading to the English geographer: a "Classical Atlas" is not in question, but a general atlas for the higher forms of schools and for the University student. There are 40 plates and 211 maps, covering every aspect of geography. The colour printing is sometimes a little crude, and areas of high relief are not always very successfully treated, but on the whole the maps are clear and easily read. Twenty-one maps are devoted to Belgium and seven to the Belgian Congo, so that the Atlas very usefully supplements the atlases produced in England and Germany in which these areas receive very scanty treatment. E. G. R. T.

ECONOMIC AND HISTORICAL GEOGRAPHY

EASTWARD HO! The first English Adventurers to the Orient. By FOSTER RHEA DULLES. *London: John Lane* 1931. 9 × 6 *inches;* xiv + 200 *pages; illustrations and facsimile maps.* 12*s* 6*d*

THE TRAVELS OF JOHN SANDERSON IN THE LEVANT, 1584–1602. Edited by Sir WILLIAM FOSTER. (Hakluyt Society: Second Series, No. LXVII.) *London: Hakluyt Society* 1931. 9 × 6 *inches;* xliv + 322 *pages; illustrations and sketch-maps*

RELATIONS OF GOLCONDA in the early Seventeenth Century. Edited by W. H. MORELAND. (Hakluyt Society: Second Series, No. LXVI.) *London: Hakluyt Society* 1931. 9 × 6 *inches;* lii + 110 *pages; maps*

When most men stayed at home books of travel were naturally "best sellers": yet still, when most men go abroad, the demand is so keen that ancient records must be ransacked to satisfy it. Those who read for recreation, and so prefer some one else to undertake the task of arranging the records, will find that Mr. Dulles, in

'Eastward Ho!' has served them well, steering skilfully between the Scylla and Charybdis of dullness and sensationalism. The five Eastern pioneers upon whose lives he pivots his story, well known though they are to the student, are less familiar to the general reader than they deserve: Richard Chancellor, whom everybody loved, and who voyaged safely into the Arctic only to perish in Scottish waters; Anthony Jenkinson, unrivalled in his knowledge of the East; James Lancaster, leader of the first East India Company fleet; Will Adams, who, despairing of seeing his wife again, wedded a lovely Japanese girl and died in exile; Sir Thomas Roe, who with his crimson doublet and scarlet cloak and hose was not eclipsed in brilliance even at Jahangir's Court.

Many will be allured by Mr. Dulles's volume to read further of the Elizabethans in the Orient, and they will find fascinating narratives, written at first hand, in the two Hakluyt Society Publications under review. Many a student must have turned the pages of John Sanderson's Journal and letter-book in its crabbed and well-nigh illegible manuscript form, and longed for patience to decipher and arrange its contents. This task Sir William Foster has performed with an ability that all must envy, and thus presents us with an amazing human document. Sanderson was not a lovable character, hardly perhaps an admirable one, but as he stands self-revealed through his letters and his autobiography, he is unforgettable. His natural irascibility exacerbated by life in the East, he falls into a rage with his apprentice, a tiresome youth enough, with his too-large washing bill and his complaining letters home. Eventually his master declares he will have the law on him, and, sitting down, casts up the expense to which the young man has put him, each item more preposterous than the last, until we come to: "My credit diminished by receiving him to be my apprentice, whom no man else would entertain, may be esteemed £1000; say but £500. . . . His father's contempt for me . . . £62," the whole sum mounting to £800! However friends seemed to have persuaded him that it would be more dignified to let the matter drop, and in later life he had nothing harsher to say of the now successful merchant than that he had been "a wild wagg." In his letters, again, Sanderson reveals himself as the sort of man we have all met: "I have always been your old friend," he writes to Sir Thomas Glover, "and therefore what I hear to your prejudice I must relate," and there follows a series of scurrilous charges against his friend who has just lost his wife. A fortnight later he has heard something fresh: "It is here reported that you do the dead lady your wife wrong, because you have not yet given her Christian burial, but have laid her in the buttery at the end of the cellar." No wonder that the unfortunate Glover is stirred to strong language: "If ever I have done so (to yet another charge), then let God damn me for ever!"

The 'Relations of Golconda' carry the reader from the Levant to India, and include one English and two Dutch reports of the Coromandel Coast and the country behind it. The Englishman, William Methwold, visited the famous diamond mines, and saw "30,000 souls, some digging, some filling baskets, some laving out water with buckets, others carrying the earth into a certain square level place, whereupon they spread it four or five inches in thickness, which being dried by that day's sun, . . . they find the diamonds among the dust." The Dutchman, Anthony Schorer, keeps fairly strictly to business matters, for he is making a business report to his employers, while the Anonymous Narrative deals more fully with social life and native customs: all alike speak of the caste system, and of the practice of *suttee*, which no Indian report of the period could pass over in silence. Methwold, like Sanderson, and every other English traveller of the period, was known to Samuel Purchas, and subscribes himself "a true lover of you and your elaborate volumes." It is customary to belittle Purchas in order to exalt Hakluyt: those who do so probably have not read him. E. G. R. T.

NAVAL OPERATIONS. Vol. V. By Sir HENRY NEWBOLT. (History of the Great War, based upon Official Documents.) *London: Longmans, Green & Co.* 1931. 9×6 *inches;* xx+452 *pages; with a portfolio of maps.* 31*s* 6*d*

By the beginning of 1917 British supremacy had been established on the surface of the seas, and was to receive only minor challenges. On the other hand, the threat from under-sea craft was developing, and had yet to be met successfully. Admiral Jellicoe summed up the gravity of the situation in a blunt warning: "We are carrying on the war at the present time as if we had the absolute command of the sea, whereas we have not such command, or anything approaching it." This concluding volume of the official naval history is concerned therefore less with regular naval operations than with methods of organization and defence of seaborne trade against enemy submarines. As Sir Henry Newbolt points out, the narrative must of necessity and to a considerable extent lack stirring incidents, for it is administrative decisions, decisive in themselves but not calculated to grip the imagination, which must be emphasized. To this there was one important exception—the storming of Zeebrugge which, though falling short of complete material success, may justly be held, from its effect upon national morale at an exceedingly critical moment, to have been among the most successful operations of the war.

The method finally employed to defeat the submarine threat was the convoy system, at first regarded with disfavour by the Admiralty. The steps by which its adoption was secured by the War Cabinet will be of interest to the student of Constitutional practice, as an example of the control of the executive by responsible ministers—and the narrative as set out here goes far to support Sir Henry's claim that it proved "the groundlessness of our old misgiving—that Cabinet government must be at a disadvantage when at war with a military autocracy."

The success of the convoy system depended upon the fact that it proved possible to obtain all necessary food supplies and minerals from the United States and Canada. This greatly facilitated the organization and protection of the convoys, though, as these pages reveal, the task remained one of extreme complication. Its success was all the more decisive, since one method of defence —the "Q" ships—was proving ineffective. Nevertheless, the protection of overseas communications continued to be a source of anxiety, in so far as its demands upon the fleet caused a diminution of the power concentrated for strategic requirements.

The only combined military and naval operation of importance which fell in this period was the brief campaign on the Dvina. Here geographical conditions were dominant. The pathless, swampy, and forested tundra limited movements to the river, free from ice during the short summer only. These circumstances compelled the abandonment of the efforts of the small expeditionary force to join up with the Czech and other bodies in Western Siberia.

In his preface, Sir Henry reveals something of the cooperative labour involved in the compilation of this work. For the Dardanelles campaign, occupying one-third of two volumes only, his predecessor, Sir Julian Corbett, had to deal with documents five times larger than the authorities consulted by Gibbon for the whole of his 'Decline and Fall.' Much is heard nowadays of the alleged antagonism between scientific and literary history: the possibility of reconciling the claims of the two is convincingly demonstrated in these comprehensive and detailed, yet most readable, volumes. G. R. C.

GENERAL

WILDERNESS TRAILS IN THREE CONTINENTS. By LIONEL A. D. LESLIE. *London: Heath Cranton* 1931. 9×6 *inches;* xvi+224 *pages; illustrations and sketch-maps.* 10*s* 6*d*

Sages and hunters of big game in the grand manner may be alike inclined to dismiss this book as of small account, and it cannot be said that the brief foreword contributed to it by Mr. Winston Churchill does much to dissuade them from doing so. From the point of view of science it contains not much that is new, its philosophical reflections are not profound, and there is a certain flatness about some of its sporting episodes that not even the slap-dash literary construction can altogether counterbalance. But as a simple record of the occupations of a young soldier, whom the urge "for to admire and for to see" has enticed from garrison life into strange corners of the world, the book will have a value for all to whom tales of strange men and beasts in unfamiliar places are of more moment than science, big game, and literature. Parts of the book are a sort of jovial aftermath from fields already harvested. Thus, the journeys from Calcutta, westwards along the Orissa coast and eastwards to Chittagong and the Arracan border, were made on reconnaissance duty and have formed the subjects of serious reports of military value; while the Labrador chapters describe some of the surroundings, trials, and diversions of an exploration party whose important discoveries were made known in a paper on River Exploration in Labrador, read before the Society in November 1929. Here and there the author is on the edge of grave matters, as at Teng-Yueh, in the Chinese Communist grip; at Puri, the heart of aggressive Hinduism; and at Chittagong, a centre of Indian communal strife. But fortunately politics are not allowed to interrupt the even flow of the author's cheerful remarks on the habits and appearance of the various jungle folk with whom he came in contact, and accounts of the wild beasts he met and sometimes managed to destroy. The illustrations, from photographs, are good, there is a sufficient index, and, on the end papers, a crude sketch-map. W. A. G.

HANDBUCH DER GEOGRAPHISCHEN WISSENSCHAFT. Herausgegeben von Professor Dr. FRITZ KLUTE. Lieferungen 11–20. *Potsdam: Akademische Verlagsgesellschaft "Athenaion"* 1930. *RM.*2.40 *per part*

The above ten Parts of the new Handbook include four on South America, devoted mainly to Brazil, contributed by Professor Otto Maull; four with the general heading of Australia which contain part only of the account of the mainland, complete sections dealing with Tasmania and New Zealand, all by Professor Geisler, and the beginning of Oceania by Professor W. Behrmann. The remaining two include a portion only of a general section on Africa and Dr. Leo Wittschell's description of North-West Africa (Morocco, Algeria, and Tunisia). This statement makes clear that we are dealing only with fragments of a whole, and the accompanying publishers' announcements do not include a general account of scope and aims. They do however emphasize the wealth of pictorial illustration, a fact apparent enough from the Parts received. The illustrations include plates, some of which are in colours and are based on paintings made on the spot, and many reproductions of photographs. If, necessarily, a proportion of the latter are more or less familiar, many are novel, having sometimes been taken by the authors of the relevant sections. Almost all are fully and carefully annotated, and definitely related to the text—a point of much importance. The illustrations both of vegetation types and of characteristic plants which accompany the account of Brazil may be noted particularly as being instructive as well as often beautiful, and both here (*e.g.* mango trees in the

streets of Manaos) and elsewhere (*e.g.* Norfolk I. pine at Napier, N.Z.) the trees shown in views of towns are sometimes named. This is a point of interest, both because it suggests that the text is written by authors personally familiar with the scenes described, and because the subject is one of some geographical importance in regard to which it is often difficult to obtain information save by an actual visit.

The maps are less satisfactory. They are relatively few in number: *e.g.* the section on Algeria has eleven text-figures and one coloured plate but only three small sketch-maps, showing the distribution of vegetation, precipitation, and Berber stocks, no general map being included. The absence of general maps, with some exceptions, is characteristic of the Parts received, but there is more than this. Not a few of the sketch-maps, mainly taken from other publications, are not only insufficient to make the text clear, but seem likely to be unintelligible to the audience presumably addressed. As one example among many we may take the map entitled Plant Formations and Cultivation in the State of Sao Paulo. There is no key map to show the position of the area, and no lettering save of four towns. Both the legend and the text lay great stress on the *Parahybagraben*, but the Parahyba is not named, nor is there, so far as we have found, a more general map on which it is shown. The weakness of the mapping both handicaps the authors and diminishes the value of what is otherwise a well-produced work.

Apart from this defect the text gives clear and generally vivid accounts of the areas named: climate, vegetation, present economic conditions and possibilities of future development and extension of settlement receiving much attention. Useful lists of references are added to the different sections. The book should be noted by geographers here particularly because of its illustrations and because its descriptions are authoritative, if simple, and are based, it would seem in most cases, on recent visits by trained geographers. M. I. N.

ALS JURNALIST UND FORSCHER IN DEUTSCHLANDS GROSSER Kolonialzeit. By HUGO ZÖLLER. *Leipzig: Kochler und Amelang* (1930). 9×6 *inches;* 456 *pages. M.*9.60

Dr. Zöller was for fifty years a special correspondent of an important German newspaper. He gives at considerable length an account of his experiences in many parts of the world, but as the title suggests his main activities were in the German colonies in Africa and the Pacific. His achievements were not purely journalistic, for he accomplished some exploratory work in the early days of the German Kamerun settlement, and later led a successful expedition into the central mountains of German New Guinea. The interest of the book however is chiefly political. He laments that the view that the German colonies could best be defended upon European battlefields prevailed in pre-war days. The Emperor Frederick, Bismarck, and President Roosevelt are among those of whom he has set down his recollections. G. R. C.

THE MONTHLY RECORD

THE NEW *LA GEOGRAPHIE*

The monthly publication of our sister society, the Société de Géographie of Paris, appeared in September in a new cover, with a new title, and under new auspices, and a notice in the number for October gives this interesting statement of the reasons for the development: To-day the Earth is entirely known; the discovery of new territories has become impossible; and the development of geographical studies must be scientific, economic, and descriptive. The Société de Géographie has therefore judged it necessary to improve the form of its Bulletin by a simplification and abundance of illustrations, to bring within the reach of all what was up to the present the privilege of a few specialists. Geography, if one understands the term in its largest sense, does not consist solely in description of the various countries of the Earth. Beside purely descriptive geography one may have a geography which is economic, historical, literary, artistic, kinematographic, touristic, and picturesque. All these kinds of geography will find a place in the Review, which is now called *Terre, Air, Mer*, and each will be studied by the most qualified and distinguished writers of the time. Each number of the Review will contain original articles, geographical news, a summary of the proceedings of the Société de Géographie, accounts of conferences, and a section *Parmi les Livres*.

The first two numbers lay special stress on the historical side of geography. We have an interesting and well-illustrated article on the part played by Pierre d'Ailly in the discovery of America, from the pen of M. Edmond Buron; a notice of Le maréchal de Rochambeau; and an article on the geographical collections of the Musée Condé by one of the staff of that Museum. Of descriptive articles there is the journal of a journey on the Cambodian Mekong by M. Georges Groslier, extending through the two numbers under review and to be continued, and a discussion on the problem of the nomads in Tunis by M. Pierre Hubac of Carthage. The section *Nouvelles et Correspondence* contains interesting notes on the geographical news of the day, and there is a section on the course of instruction in geography in French-speaking universities of Europe. The Review is printed on very shiny paper to allow the use of half-tone blocks in the text.

The new title, which presents to us a little problem in pronunciation, does not entirely supersede the old title *La Géographie*, the two appearing in various combinations and with varying emphasis: *La Géographie* perhaps for the members of the Société de Géographie who receive the Review of right, and *Terre, Air, Mer* for the great public, which will no doubt be enticed by the new cover and the rhyming title. We have said also that the Review appears under new auspices. It is copyrighted by the Société d'Éditions Géographiques, Maritimes et Coloniales à Paris, from the address 184, Boulevard Saint-Germain, which is the old address of the Société de Géographie. The Review is published monthly by the Société de Géographie and the Société d'Éditions Géographiques. It is edited from the new house of the Geographical Society in the Avenue d'Iéna, but subscriptions are payable in the Boulevard Saint-Germain, and the responsibility for the Review appears to be no longer entirely in the hands of the former, since the imprint gives as Joint Directors, MM. G. Grandidier and Hubert Morand.

British students of geography will view with some regret the disappearance of the well-known journal published on the sole authority of the Société de Géographie, but will study with interest the new development of popularization. Geographers of Great Britain and of the United States will however note with

some surprise a discrimination against them. The twelve months' subscription for France and her Colonies is 75 francs. A large part of the world, including Abyssinia, Turkey-in-Asia, and the U.S.S.R., may subscribe for 90 francs, but the United States, Great Britain and Ireland, and the British Dominions beyond the seas other than Canada, Newfoundland, and the Union of South Africa, are required to pay 105 francs, which is discouraging.

THE MERAPI VOLCANO, JAVA

Among the many volcanoes of Java those of Merapi and Kelut have been distinguished of late for the violence of their outbursts, which have been studied by various Dutch observers, particularly Dr. G. L. L. Kemmerling. The destructive eruption of Merapi towards the end of 1930 is the subject of a detailed discussion by him in the *Tijdschrift* of the Netherlands Geographical Society, July 1931, based in part on an official report by Dr. M. Neumann, head of the Volcano Research Department of the Netherlands Indies. After the last serious eruption of the volcano in 1920–21 Dr. Kemmerling had established an observation station on its western slopes, but this was unfortunately destroyed in last year's catastrophe, so that the data are not so complete as they might otherwise have been. After a preliminary display of activity in November and early December, this took on increased violence on December 18, when some 1300 of the dwellers on the western slopes fell victims to the fiery blast which issued from the mountain accompanied by an outpouring of incandescent lava-rubble which on that day, and still more on the 19th, filled the ravines of the Blongkeng and other streams which furrow the western slopes. By piecing together the information collected Dr. Neumann had drawn certain conclusions as to the course of events and character of the eruption, the prime cause of which was the opening of a breach on the west flank of the mountain. He considered that this occurred in successive phases, beginning with the formation of a new vent (that of 1920–21 having in his view become blocked) and a new lava-plug, followed by a fissure-eruption and gaseous explosion. Dr. Kemmerling dissents from this view, maintaining that both the breach and the lava-plug were the same as those of 1920, since which year the volcano had never been completely quiescent. He also holds that there was no fissure-eruption and no deep-seated explosive action, but that the eruption was in the first instance effusive, the discharge of gases being a secondary phenomenon, after the lava had come to the surface. He gives much attention to different forms of *débâcle* from which the neighbourhood of the volcano suffers from time to time, distinguishing those in which water is the moving force in the streams of debris from those due to outpourings of lava. (The water may be derived either from rain, in the S.W. Monsoon, or from the bursting of crater-lakes.) The lava streams appear almost dry, and it is not easy to account for the way in which they are forced onwards down slopes of slight gradient. In view of the very different character of the two forms he holds that the native term *lahar* should not be applied equally to both, but should be restricted to the streams carried forward by water. Again a careful distinction is necessary between the incandescent streams of lava debris and the incandescent clouds which emanate from them (being formed of the lighter particles), but may take quite different directions as they advance downwards. This distinction was also made by Lacroix in discussing the Mont Pelé eruption of 1902, to which that of Merapi last year presents a close parallel. Dr. Kemmerling insists that the danger from the mountain cannot be regarded as over, and that it should continue to be carefully watched. For this purpose a new station has been established to replace that destroyed in December last.

MOUNTAIN AND VALLEY PRECIPITATION IN UTAH

In an arid region like Utah, the bulk of the water supply for agricultural and industrial purposes comes from the precipitation on the mountains, whereas, owing to inaccessibility, there are comparatively few records available from these. This gives interest to a study by Mr. G. D. Clyde, published in the *Monthly Weather Review* for March 1931, of the comparative precipitation on mountains and adjoining lowlands in the Cache valley of Northern Utah based on regular observations during the past few years. The valley, which is the site of the old Lake Bonneville, lies in Northern Utah, the whole catchment area covering some 450 square miles. The floor is a slightly undulating plain, gradually sloping up to the foothills of the mountains, which are high and rugged, especially on the east, the highest summits exceeding 9000 feet. Cyclonic storms are the source of most of the precipitation, which averages from 11 to 21 inches on the valley floor, increasing regularly with altitude. On the mountains the summer precipitation is very irregular, being in some years slightly greater, in others less than in the lowland, so that valley records are of little use as indicators of summer precipitation on the mountains. The winter precipitation on the latter is almost entirely in the form of snow, and its amount can be approximately estimated by the snow surveys carried out regularly since 1923. It is uniform over wide areas, and, as might be expected, is very much greater than that in the valley, the seven-year mean at three stations being over 30 inches. But it again shows no definite relation to the valley figures, so that the latter are a poor index to the probable supplies. On the other hand the mountain precipitation above 8000 feet seems to give a good indication of stream-flow in this area.

EARLY ERUPTIONS OF VESUVIUS

The compilation of a full catalogue of volcanic eruptions in the past is a difficult matter, and a recent short article by P. Preusse on those of Vesuvius in the sixteenth and seventeenth centuries (*Zeitschrift für Vulkanologie*, Band xiii, Heft 4) shows that even for this volcano we may still be far from a complete record if minor displays of activity are taken into account. It has been a common belief, which holds its own to some extent even at the present day, that the great eruption of 1631 was preceded by a lengthened period of almost entire passivity, which is far from being the case. The writer points out that local observers often fail to record the less important displays of activity, taking them as a matter of course, and that records have rather to be looked for in narratives of foreigners. Five such foreign visitors supply valuable data for the period in question, while the number of native authorities is hardly greater. Herr Preusse has been at pains to bring together all the records available for the period 1500–1647, the total number amounting to well over twenty. Some refer only to the occurrence of smoke or fumaroles, while one or two (including the account of the English traveller Sandys) seem to imply a state of rest. An important find has been the original account by the Venetian statesman and philosopher, Daniel Barbarus, generally quoted at second hand, respecting the eruption of 1567, though the editor of the *Zeitschrift*, Dr. Friedlaender, takes a view of the nature of the occurrence described somewhat different from that of Herr Preusse. For the period 1632–44, for which few data have so far been available, the latter has found some useful notices in the *Gazette de France*, from which he prints extracts.

ISLAND ARCS AND MOUNTAIN BUILDING

In a letter to the Secretary, dated Maymyo, Burma, 11 September 1931, Major Kenneth Mason writes:

"I was very much interested in Lake's paper in the August *Geographical*

Journal on Island Arcs and Mountain Building. A point struck me when tracing on a larger map the trends of the East Indian and Himalayan Arcs. I had been following out the grain of mountain trends in Nepal, Assam, and Burma from our most recent maps, and comparing this with the strike where known, and I noticed that the East Indian arc if produced follows the grain (and probably the strike) of the Arakan, Chittagong, and Lushai Hills. Both these arcs appear to be somewhat flattened as they approach each other. Exactly at their point of contact the Brahmaputra forces its way through. This seems to me to have some significance, but I dare say has been already noted.

"In the last paragraph on p. 154 Lake says, 'A movement of the mass as a whole in both directions is not possible.' It seems to me quite possible provided the two movements are not simultaneous. I do not know when the island arcs of Kurile, Japan, and Riu Kiu were formed, but I believe the Yomas of Burma, and therefore possibly the East Indian arc, were formed in Jurassic times before the elevation of the Tibet plateau and Himalayan arc, though they are of course much lower.

"It seems to me that the question of the direction of thrust, whether over-thrust or under-thrust, is related to time. North-east of the Brahmaputra bend and dividing the Salween, Mekong, and Yangtse, the mountain arcs seem to be reversed with the poles to the south-west. Might this not indicate that these arcs were formed by an over-thrust from the south-west or an under-thrust from the north-east when the Gondwana continent and the Tethys sea were existing?"

Mr. Lake, to whom the letter was submitted, kindly sends the following reply, and adds that he is glad of the opportunity to make clear the question in the second paragraph:

"There can be no doubt, as Major Mason suggests, that the western Burmese ranges are the continuation of the East Indian arc, and that the Brahmaputra breaks through where the Himalayan and East Indian arcs meet. In my paper I refrained from dealing with such junctions because any adequate treatment would have introduced complications which were unnecessary for the general argument. Here it will be enough to indicate that on my hypothesis the spherical form of the Earth may require some adjustment of the superficial folds where two arcs meet and that the adjustment may take place in several ways. Incidentally it may be noted that at the other end of the Himalayas there is a similar but less sharply defined meeting of arcs, and here the Indus breaks through.

"The quotation queried by Major Mason in his second paragraph certainly requires explanation. My meaning was that the Asiatic mass could not move as a single unit in both directions *at the same time*. All the arcs shown upon my map are approximately contemporaneous. The movement to which they are due may not have *begun* everywhere at the same time, but in all it was predominantly Tertiary and, since all the arcs are still belts of disturbance, it probably continues to the present day. Major Mason, writing from memory, is wrong in ascribing a Jurassic age to the Burmese Yomas. They are Tertiary chains, and even Pliocene beds are involved in the accompanying folds. A short summary of the geological history of Burma is given by Pascoe in 'The Oil-fields of Burma,' *Mem. Geol. Surv. India*, vol. xl, p. 248.

"My own suggestion is that the Asiatic mass is neither moving nor breaking up, but that there is under-thrusting on both the eastern and the southern sides. The alternative is that the eastern and the southern parts of the mass are moving independently, and the mass must be breaking up. As for the mountain arcs north-east of the Brahmaputra bend, I should not like to express any opinion until more is known about their geology."

PERMANENTLY FROZEN GROUND IN CANADA

With the spread of mining and engineering operations in Northern Canada a knowledge of the character and extent of its permanently frozen ground is becoming important. Mr. W. A. Johnston brings together data in an article entitled "Frozen Ground in the Glaciated Parts of Northern Canada," which makes reference to papers on the subject appearing in the *Proceedings* of the R.G.S. for 1885, 1886, and 1887 [*Transactions* of the Royal Society of Canada, section iv, vol. xxiv, pt. 1, 1930]. The chief regions dealt with are the Yukon, Mackenzie, and Northern Manitoba. In the Yukon frost penetrates to a great depth, which however varies considerably, being greater in the valleys than on the ridges, and greater in the unglaciated Klondike district than in the parts of the Yukon which have been glaciated. In Northern Manitoba a good deal of information is available from many borings in connection with the Hudson Bay Railway at Port Nelson and Churchill. Here practically no frost was found beneath the tidal muds, but in one boring inland frozen ground was found at a depth of 115 feet separated by an unfrozen layer from an upper frozen layer.

Although the depth of the frozen ground is generally lower in the colder northern regions the relation between it and the mean annual temperature of the air is not very close. Thus whereas at Dawson, Yukon, where the maximum depth of the frozen ground is at least 200 feet, the mean annual temperature is about 23·5° F.; at Norman, in the Mackenzie Valley, where the depth is only about 40 feet, the mean temperature is only 20° F. This anomaly inclines the author to infer that the great depth at Dawson is not entirely due to present climatic conditions but is an inheritance from the glacial period, though he admits that the Mackenzie River may have some influence in diminishing the depth at Norman. It is evident however that a much wider survey is needed before safe inferences can be drawn. Fossil ice is certainly known to exist in Siberia, Finland, and other cold countries, but it should never be assumed without an exhaustive examination of present-day meteorological and hydrological conditions. It has even been argued that the great Vatna Jökull in Iceland must be a legacy from the Ice Age because that country is warm for its latitude, regardless of the fact that it is just that relative warmth which makes Iceland an extremely snowy country especially at any altitude.

LINCOLNSHIRE COAST EROSION

In an article entitled "The Post-Glacial Deposits of the Lincolnshire Coast," published in the *Quarterly Journal of the Geological Society of London* (vol. lxxxvii, pt. 2, 1931), Dr. H. H. Swinnerton describes the results of detailed researches which he has made along the portion of the coast of Lincolnshire between Mablethorpe and Skegness. He concludes that whereas the coasts north of Mablethorpe, in the shelter of Spurn Head and south of Skegness within the shelter of the Wash, are regions of deposition, the strip between those two towns is being eroded in consequence of the removal at no very distant date of sand-banks in the North Sea which formerly protected it. The country behind this middle strip of the coast extending to the Wolds forms the Lincolnshire Marsh and is shut out from the sea by a prominent line of sandhills. Near the Wolds the surface is formed of boulder-clay and is well wooded, but nearer the sea it is clays of estuarine origin and nearly treeless. Behind the dunes the marshland clays are heavily blanketed with sand, which as it drifts southward becomes broken by valley-like hollows often more than a mile long extending obliquely across the beach. These hollows, scoured by strong and dangerous currents which sweep away the sand and erode the clays beneath, offer extensive exposures of the whole succession of post-glacial clays that occur in the Fenland and

Marshland. At the lowest level there is peat with tree-stumps rooted in boulder-clay, and it can be estimated that at the time the trees were growing the relative level of land to sea was at least 25 feet higher than it is now. At Ingoldmells Point and elsewhere Roman remains were found in the marshland drains excavated in the upper post-glacial deposits, so that no appreciable subsidence of the coast could have occurred till the latter part of the Roman occupation. It is shown from a map of the configuration of the neighbouring sea-floor that such banks as the Protector Overfalls, Inner Dowsing, and Docking Shoal could, when higher, have effectively sheltered the shore from the severe erosion that now takes place and permitted the settling of the post-glacial sediments in quiet estuary waters formed by the virtual extension through the said sandbanks of the channel known as Boston Deep in the Wash. The subsequent removal of the barrier by the sea could not, from the evidence of still later deposits, have occurred till long after the Roman occupation, and it is suggested that it occurred during the severe east coast tidal devastations towards the end of the thirteenth century.

STATISTICAL ANNUAL OF GREECE

We have received from the Greek Statistical Office a copy of the 'Annuaire statistique de la Grèce, 1930, Année 1,' which has no doubt been inaugurated to mark the centenary of Greek independence. This volume, which is printed in Greek and French, gives in compact form a mass of statistics under three headings—Territory and Population, National Economy, Political and Social, and is illustrated by a number of graphs and sketch-maps showing distributions.

The population of Greece as returned at the census of 1928 was 6,204,684. This was an increase of 673,210 over the figures for the census of 1920, but the result is complicated by territorial adjustments and migration. Between 1920 and 1928 the area of Greece was decreased by the loss of Eastern Thrace, Imbros, and Tenedos. The resulting diminution of population has been compensated by a great influx of refugees. These numbered, in 1928, 1,221,849; over 50 per cent. of this total had come from Asia Minor, and of the remainder, more than two-fifths from Thrace. A large proportion of these immigrants have settled in Macedonia. Of the population over eight years of age 42 per cent. were returned as illiterate.

The balance of trade, in "commerce special," was in 1929 heavily against Greece, the imports practically being twice the value of the exports. The chief countries importing into Greece were the United States, 16 per cent., and Great Britain 13 per cent., followed by Germany and France. On the other hand the countries to which the greater part of Greek exports went were Germany 23 per cent., and Italy 18 per cent. With these last two countries the balance was definitely in favour of Greece.

BECKIT MEMORIAL FUND

Old students of the Oxford School of Geography have raised a fund to establish in Oxford a Geographical Award in memory of the late Reader of Geography, Mr. H. O. Beckit. Any other friends who would like to join in this project are invited to send their contributions to Miss N. G. MacMunn, at the School of Geography, Oxford, before December 31.

CORRESPONDENCE

THE NEW ONE-INCH ORDNANCE MAP

An article in the *Geographical Journal* for October 1931 gave a description of the excellent new type of 1-inch map which has recently been adopted. It may perhaps be interesting to note that but for the War a map, generally of this type, would have been adopted towards the end of the year 1914, seventeen years ago. In the Report of the Progress of the Ordnance Survey for the year ending 31 March 1914, the then Director-General remarked: "It was mentioned in my report of last year that it was not likely that any of the sheets of the new type of 1-inch map would be published before the year 1914. Many of these sheets are now in an advanced state of preparation, but none will be actually printed before this Report is issued. It is expected however that some will be available during the course of the summer. In addition to improving the representation of the hill features, care has been taken to make the classification of the roads a suitable one for modern needs. . . . A special 1-inch map of the Killarney District was published during the year in a style somewhat similar to that of the new series."

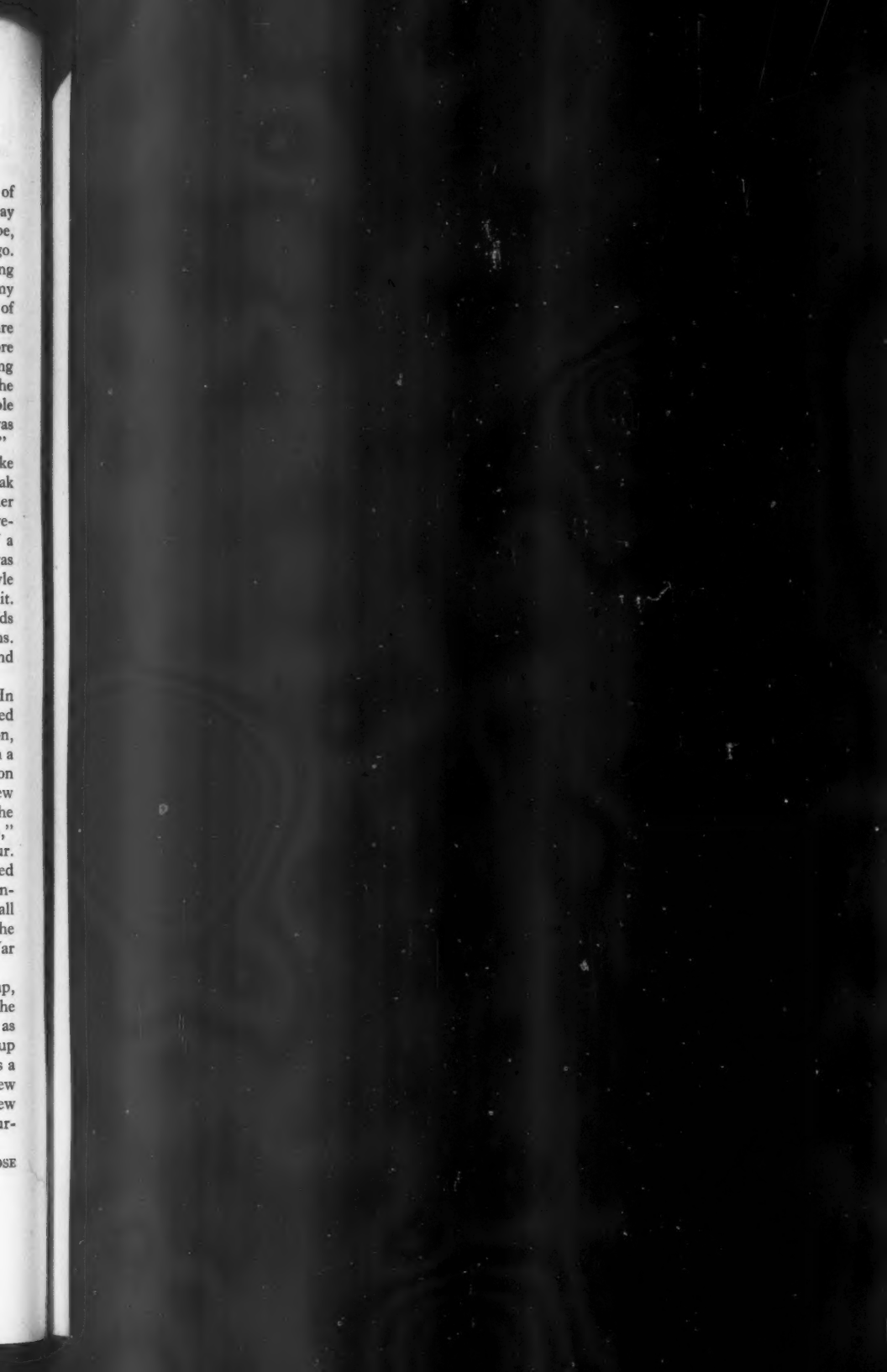
This Report was signed on 28 April 1914, and, as we all know, the War broke out a little over three months from that date. From the moment of the outbreak of the War, the new map was put utterly aside, and it may be doubted whether any of the plates, of the sheets that were almost ready for printing, were preserved. After the War it became necessary to expedite the preparation of a revised edition of the 1-inch map, and a less pictorial and less elaborate style was adopted—a style that could be more rapidly produced. But the pictorial style was abandoned with regret, especially by those who had worked to perfect it. The "Popular Edition" thus made its appearance, clean and clear, with the roads easily legible, but with reliance only on contours to show the ground-forms. The contours were however increased to a 50-foot interval for the first time, and these 50-foot contours are again employed on the new map.

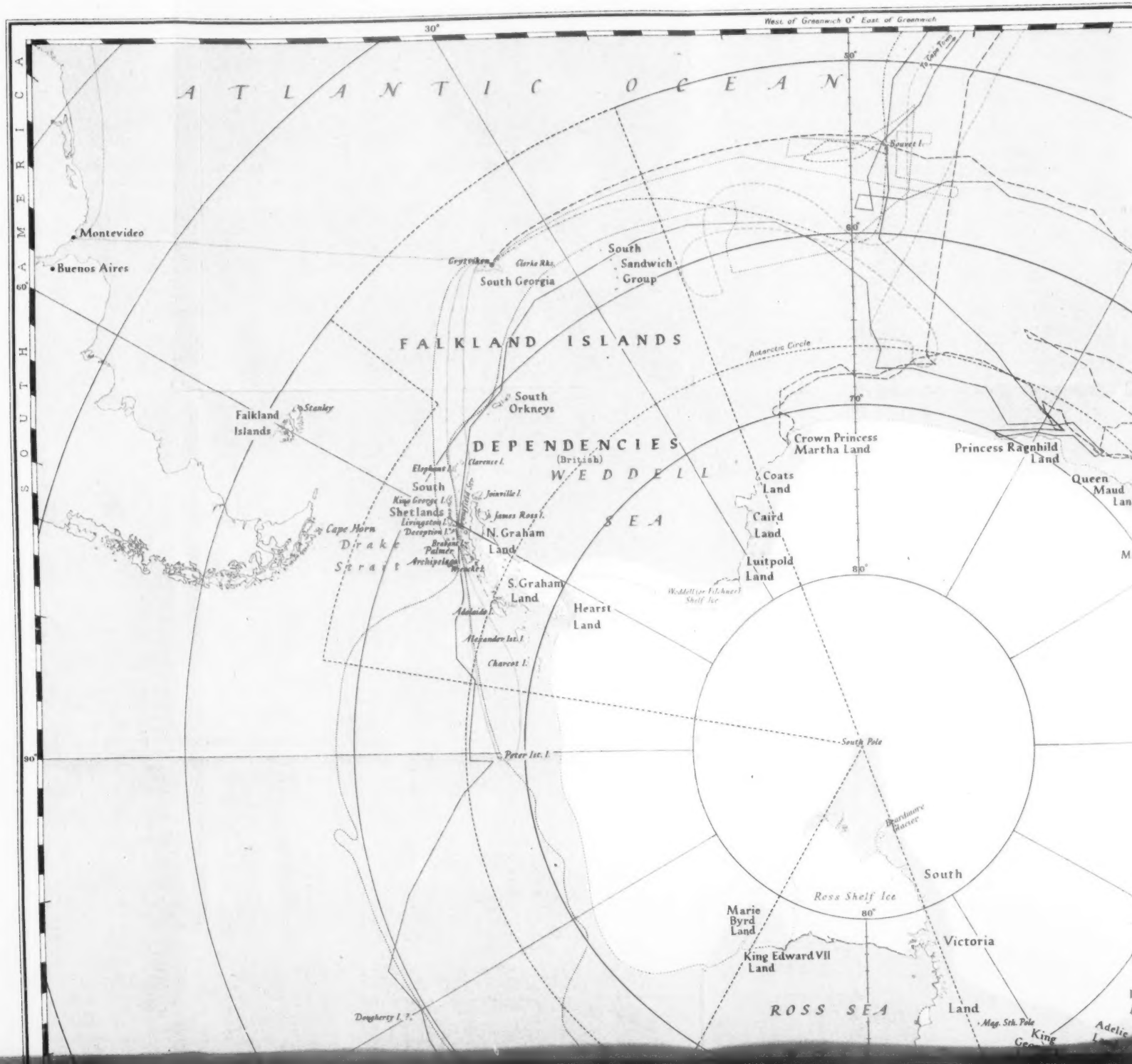
However we are not left to guess what the style of the "lost map" was. In reasonable anticipation of the issue of the map, an advance specimen was printed in the 'Text Book of Topographical and Geographical Surveying,' second edition, 1913, and this (Plate XXIV) will be found after page 184 of that work. From a study of this Plate it appears that the hill-features were shown by a combination of "layer" tones, hachures in a yellowish shade (much the same as on the new map), and grey shading on the south and east sides of the hills (again, much the same as on the new map). The principal difference is that, on the "lost map," the lowest "layer" tone was a light green from sea-level to the 300-foot contour.

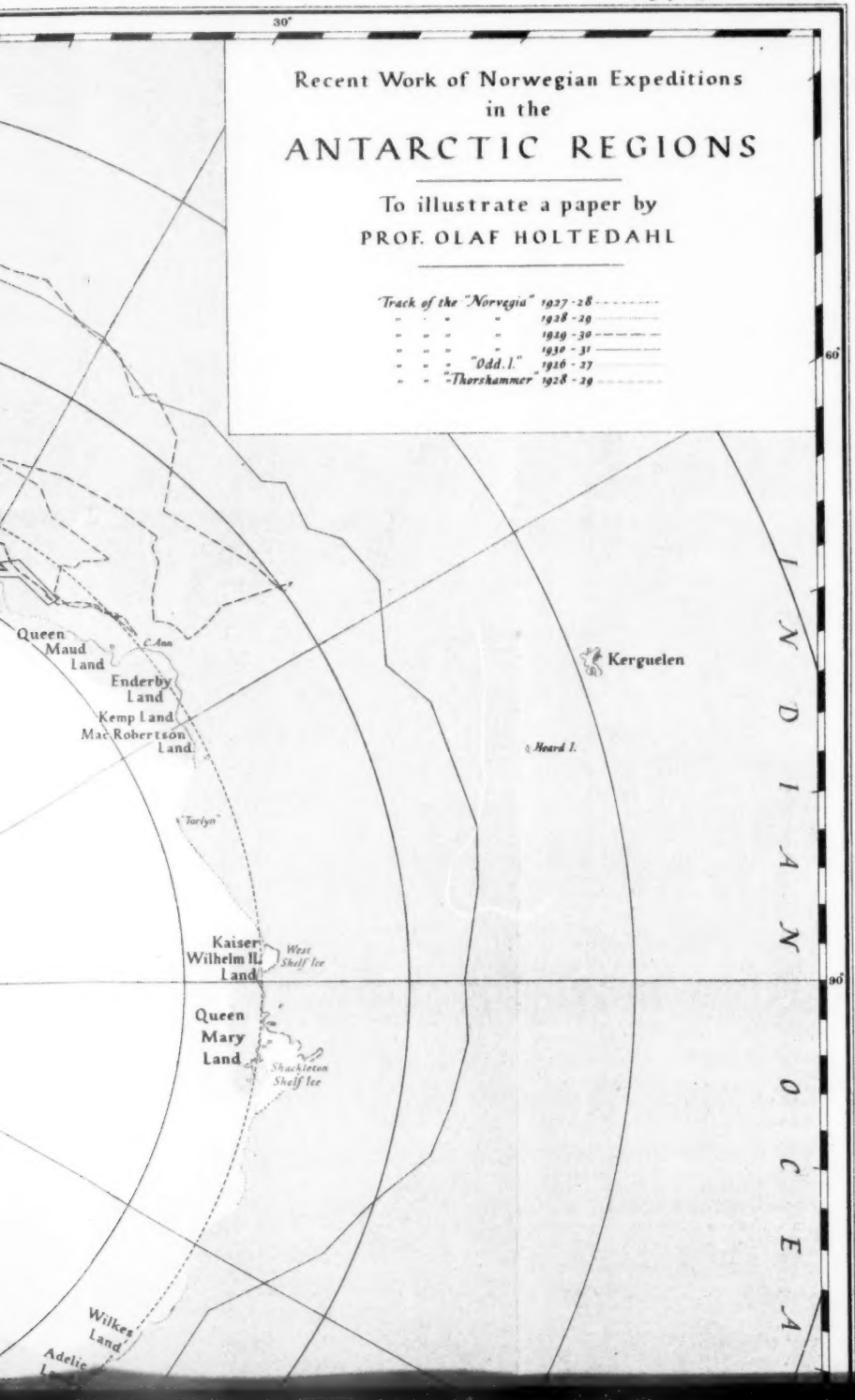
It is interesting to note the general similarity between the two maps, separated by an interval of seventeen years. This similarity is evidence of a general continuity in the working of the Department responsible for both, a continuity all the more effective because the present Director-General was, for a time, in the pre-War period, responsible for the preparatory studies resulting in the pre-War pattern, which was never issued owing to the outbreak of the War.

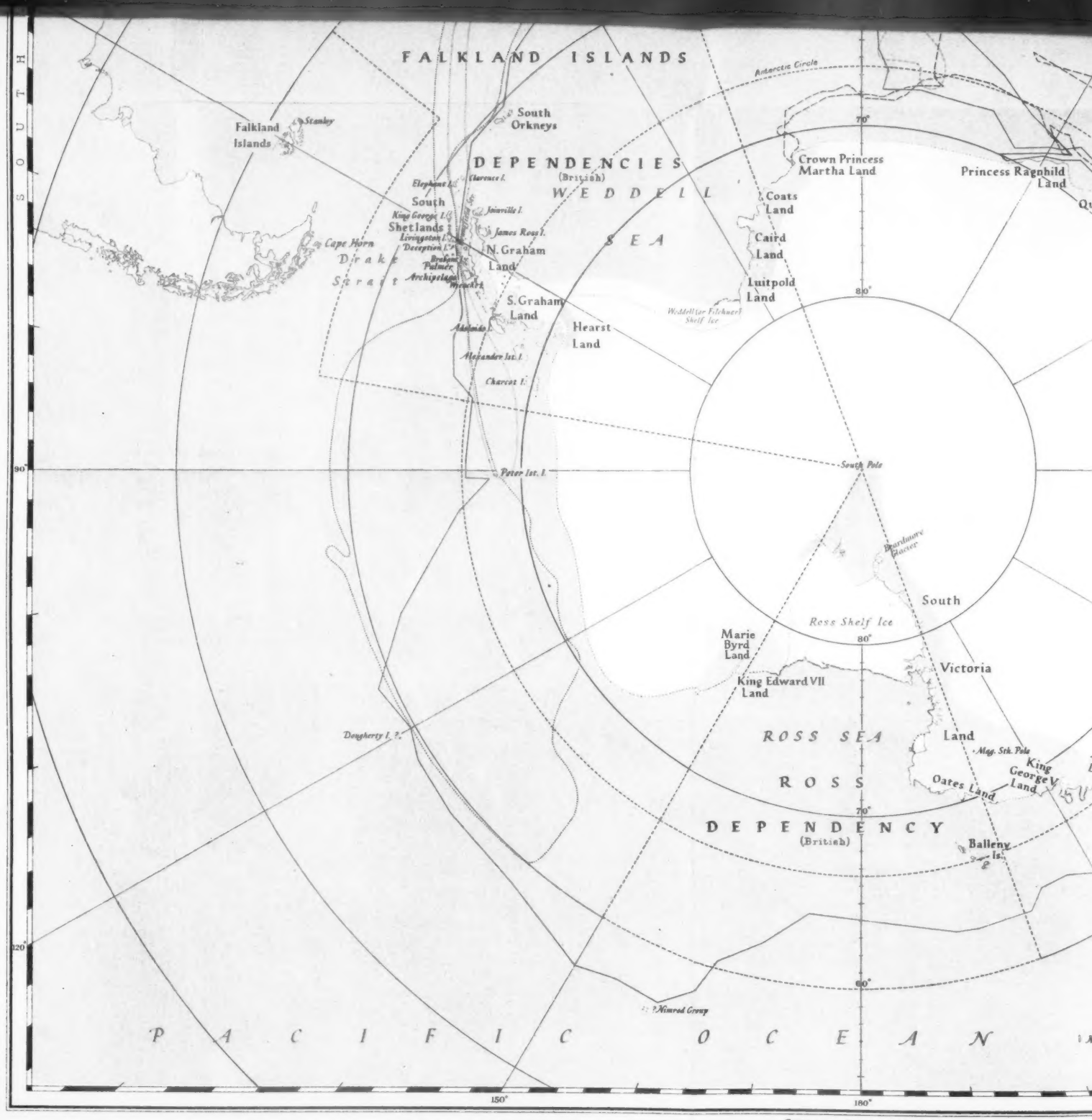
It is understood that there will shortly be issued an edition of the $\frac{1}{2}$-inch map, which is on generally the same lines, except that, in the absence of hachures, the old hill-shading plates have been used, partly as hill-shading, and partly as shadow. The roads and the more important alterations have been brought up to date. This new form of the $\frac{1}{2}$-inch map will probably first be produced as a district map of the Cotswolds; afterwards the sheets will be issued on the new grid and projection, as the stocks of the old form become exhausted. The new map has many merits, and should prove most useful for a great variety of purposes, notably for motoring. It is a pleasant map to look at, and easy to read.

C. F. CLOSE

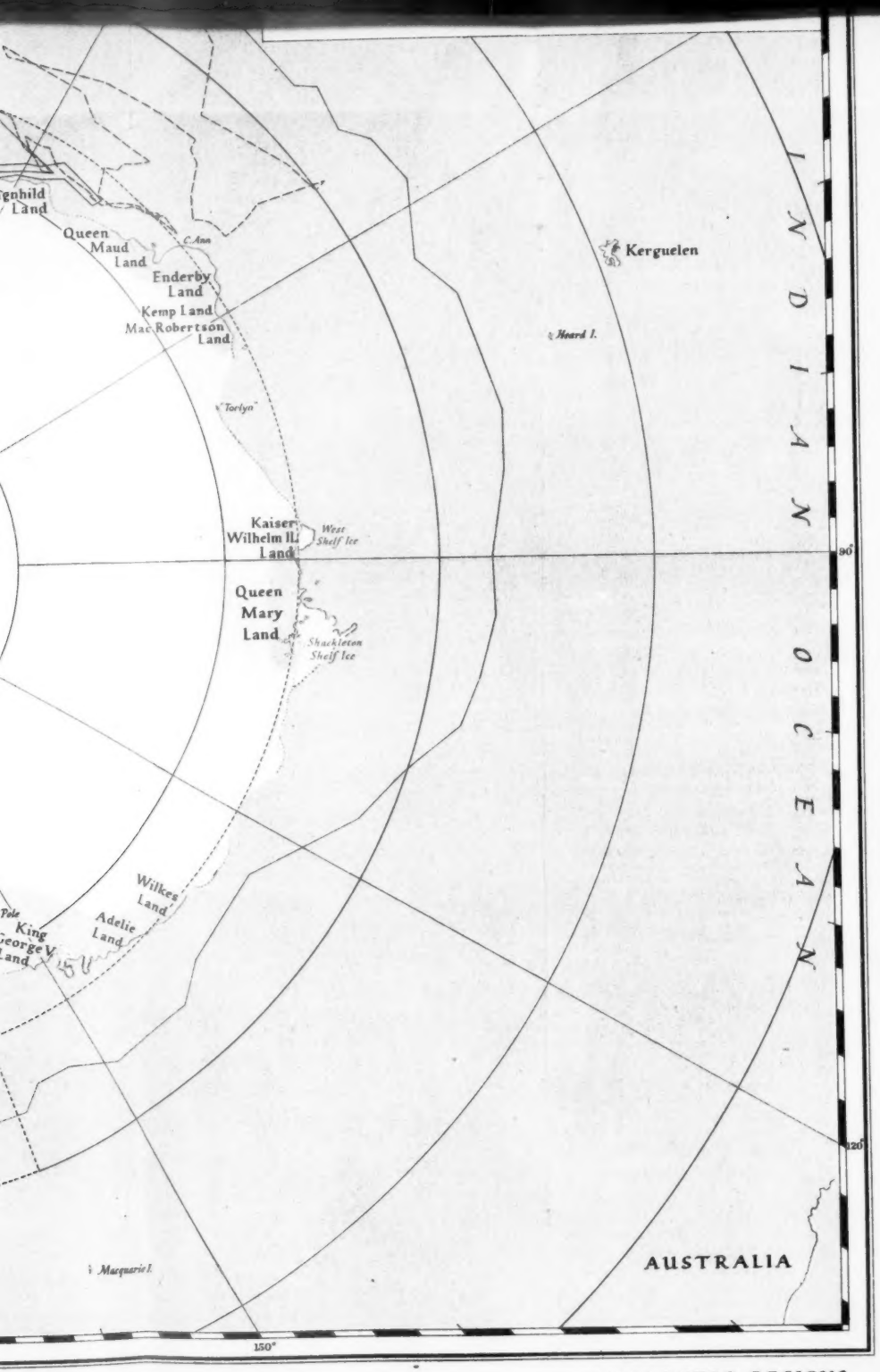



West of Greenwich 0° East of Greenwich
30°
ATLANTIC OCEAN
SOUTH AMERICA
Cape Town
Bouvet I.
60°
Montevideo
Buenos Aires
Grytviken
Clarke Rks.
South Georgia
South Sandwich Group
FALKLAND ISLANDS
Antarctic Circle
70°
Falkland Islands
Stanley
South Orkneys
DEPENDENCIES
(British)
Crown Princess Martha Land
Princess Ragnhild Land
Queen Maud Lan
Elephant I.
Clarence I.
WEDDELL SEA
Coats Land
South Shetlands
King George I.
Joinville I.
James Ross I.
Caird Land
Cape Horn
Drake Strait
Livingston I.
Deception I.
N. Graham Land
Brabant Is.
Palmer Archipelago
Wrecker Is.
Luitpold Land
80°
S. Graham Land
Weddell (or Filchner) Shelf Ice
Hearst Land
Adelaide I.
Alexander Ist. I.
Charcot I.
South Pole
90°
Peter Ist. I.
Beardmore Glacier
South
Ross Shelf Ice
80°
Marie Byrd Land
Victoria
King Edward VII Land
ROSS SEA
Land
Dougherty I.?
Mag. Sth. Pole
King
Adelie


30°
Recent Work of Norwegian Expeditions
in the
ANTARCTIC REGIONS
To illustrate a paper by
PROF. OLAF HOLTEDAHL
"Track of the "Norvegia" 1927-28
" " " " 1928-29
" " " " 1929-30
" " " " 1930-31
" " "Odd. I." 1926-27
" " "Thorshammer" 1928-29
60°
90°
Queen Maud Land
C. Ann
Enderby Land
Kemp Land
Mac Robertson Land
"Torlyn"
Kaiser Wilhelm II. Land
West Shelf Ice
Queen Mary Land
Shackleton Shelf Ice
Wilkes Land
Adelie
Kerguelen
Heard I.
INDIAN OCEAN



Published by the Royal Geographical Society



ANTARCTIC REGIONS
Holtedahl